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PENSACOLA FLORIDA

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SUMMARY PAGE

THE PROBLEM

The Pendular Eye Tracking Test (PETT) is conducted under a variety of conditions that may influence the range of variation in response among normal subjects and the diagnostic significance of the test in its clinical application. This report describes normative data collected under two conditions of viewing a moving target, with and without a visible background.

FINDINGS

Normative data are presented in a compendium of electro-oculographic records from 60 "normal" subjects who viewed a target moving sinusoidally at 0.5 Hz with peak velocity initially at 60 deg/sec and diminishing to 30 deg/sec in 60 seconds. The target light was viewed 1) against a dim background of vertical black and white stripes and 2) in darkness. Typically, pursuit tracking was good under both conditions, but statistically significant, albeit small, differences favored pursuit tracking with the background visible. It is suggested that the peripheral retina aids visual pursuit tracking, that pendular eye tracking tests have different pathognomic potential under the two viewing conditions, and that the test should be conducted under both conditions.

PART I. A COMPENDIUM OF PENDULAR EYE TRACKING RECORDS FROM SIXTY NORMAL SUBJECTS

Kimberly S. Davenport, Catherine B. Brewton,
Gene T. Turnipseed, and Fred E. Guedry, Jr.

INTRODUCTION

Assessment of visual pursuit tracking of a sinusoidally moving target has been found useful in the diagnosis of several conditions that cause vertigo and disequilibrium (1,5,7,15-17). The assessment procedure, sometimes referred to as the Pendular Eye Tracking Test (PETT), differs from one laboratory to another. Aside from variations in size, brightness, oscillation frequency, and peak velocity of the moving target, there are variations in the visual background against which the target is viewed that may influence both the consistency of performance in normal subjects and also the pathognomic significance of the procedure with clinical referrals.

In preliminary tests erratic tracking patterns were obtained from a fairly high percentage of a small group of "normal" subjects when a light spot was projected onto a screen in a dark room. The stimulus device (optokinetic stimulator, LT Instruments Model 3400) projects a light beam through a moving circular film strip with a sinusoidally displaced transparent stripe. The system produces a fairly large moving spot that changes shape at the extreme of each excursion and also yields occasional erratic motion of the film strip. On the presumption that these characteristics had contributed artifactious response variation, we chose to use a point light source contained within a pendulum bob as the visual target. At the same time, we became aware of results obtained by Benson and Cline (3), indicating that visual suppression of vestibular nystagmus by a head-fixed target seemed to be improved by uniform motion in the peripheral visual field. This suggested that ability to hold foveal fixation (cf. 10,14) might be strengthened by motion stimuli in the peripheral retina, which in turn suggested that the presence or absence of a visible background might influence both the diagnostic significance of PETT and the range of variation in PETT results among normal subjects. The present report presents pendular eye tracking records obtained with and without visible background in a fairly large group of normal subjects. It, therefore, affords a comparison of the effects of different background conditions and also provides a normative data base for each condition.

PROCEDURE

Subjects

Sixty healthy young naval officers, average age 24 years, who had 20/20 vision or better, either naturally or with optical correction, served as volunteer subjects. All were in pilot training or naval flight officer training and had recently passed flight physical examinations.

Apparatus

A small horizontal shaft between two small, carefully aligned, precision bearings served as the suspension for a pendulum. A low torque precision potentiometer coupled to one end of the shaft provided a means of recording pendulum motion. A small-diameter (6 mm) aluminum rod with brass bob adjusted about 90 cm from the pivot point provided a pendulum with a period of 2.0 seconds. Attached to the base of the bob was a hollow aluminum block containing a Chicago miniature lamp (T - 1 3/4 bulb style midget flanged base 28 V DC), which could be viewed through a 1-mm aperture in the aluminum block. Covering the aperture, a small circular spot of white paper diffused the bright light from the bulb (powered by 10 V DC supply) to provide a small bright spot clearly visible in the dark condition and also in the dim illumination condition. The entire pendulum apparatus was painted flat black. A background screen, 122 cm x 122 cm, of vertical black and white stripes was 16 cm behind the pendulum. Each stripe was 3.56 cm in width. Brightness levels of the white and black stripes were 0.0826 apparent foot-candle and 0.0045 apparent foot-candle, respectively.

The subject was seated with head positioned in a chin and forehead rest so that his straight-ahead line-of-regard would be horizontal when directed at the target light with the pendulum resting in its vertical position of static equilibrium. Eye-to-target distance was 99 cm.

Electro-oculography was used to record eye movements, using silver-silver chloride electrodes and direct-coupled amplification. Electrodes were affixed in the standard position for recording horizontal eye movements and allowed to stabilize for approximately 15 minutes prior to recording.

Method

Subjects were instructed to remain alert and to carefully follow the target light. If, during the course of the test, tracking appeared to be erratic, brief reminders were given concerning the importance of remaining alert and making a good effort to track. Initial instruction was completed and calibrations obtained in dim illumination in the test room. This allowed additional time for electrode stabilization and partial dark adaptation.

For each subject the first test was conducted in dim illumination with the black and white striped background visible behind the target light, and the second was conducted in darkness with only the target light visible. To commence each test, the pendulum bob was displaced 20-degree visual angle to the subject's right and then allowed to swing free for 60 seconds. The time constant of decay in pendulum motion was 72 seconds so that when the test was terminated, the peak displacement of the pendulum had diminished to a peak angular displacement of subject's eyes from his central line of regard of about 9 degrees. With an initial angular displacement of 20-degree visual angle (pendulum frequency of 0.5 Hz) sinusoidal eye movement with

a peak velocity of about 63 deg/sec was required for perfect visual pursuit in the first cycle, diminishing in 60 seconds to a peak angular velocity referred to the subject's eye of about 27 deg/sec.

Eye movement calibrations were obtained before and after each test, and thus several minutes of rest from visual pursuit tracking were afforded the subject between the first and second test. Tracking in darkness was always conducted as the second test on the presumption that there is some improvement of pendular eye tracking with practice (11) and prompting (18, p. 403). If such practice effects were present in our data, then our procedure was biased to yield better tracking in the dark condition, other factors remaining constant.

RESULTS AND DISCUSSION

The results are presented as a series of thirty figures (Figures 1-30), each of which presents photographs of record segments from two of the subjects under the two test conditions. Numbers on the records are shown solely for identification of subjects. Each line of record is about 14 seconds in length, the second of the two lines under each condition being approximately a continuation of the first. Slightly less than half of the record from each test period is shown. Most record segments were taken from an interval beginning a few cycles after the starting point of the test.

Several points emerge from perusal of this compendium:

1) Most subjects produce good sinusoidal pendular eye tracking under both viewing conditions. Of the sixty subjects, only three (#21, #45, and #50) yielded records that showed anomalies on most cycles under both conditions. One subject, #45, produced a fairly consistent stepping pattern, but an occasional smooth cycle suggests that the anomalous cycles might be corrected by greater effort (20, p. 278). The other two subjects yielded "cogwheeling-type" records, though neither is extreme and either could result from artifacts or residual drug effects (11,15,20). In practice, a retest would be appropriate for these three subjects and perhaps one or two others.

2) While smooth visual pursuit was typically good under both viewing conditions, there appear to be very few comparisons (three or four) where it appeared to be better in the dark than in the dim illumination condition, whereas there are a number of comparisons in which slightly superior pursuit tracking occurred during the dim illumination condition. A more detailed comparison of the entire record obtained for each subject under the two viewing conditions is presented in Part II.

PART II. A COMPARISON OF PENDULAR EYE TRACKING WITH AND WITHOUT A VISIBLE BACKGROUND

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INTRODUCTION

In considering tests of visual pursuit of a target light in darkness, Hood and Leech (14) noted the unusual nature of this viewing condition relative to conditions routinely encountered in our daily lives, wherein moving objects are tracked against complex stationary backgrounds. During smooth visual pursuit, foveal images of the target must remain relatively fixed while a plethora of visible background images traverses the peripheral retina in a direction that would, as an optokinetic stimulus, generate pursuit movements in a direction opposite that required to maintain foveation of the moving target. From such considerations they propose that in typical visual pursuit, "... two separate and distinct channels of information must be transmitted to the brain, one derived from the fovea and the other from the peripheral retina," and they suggest that the peripheral retina might be used to advantage as a controlling mechanism aiding stability of pursuit eye movements. It also follows that if two separate and distinct channels are involved in normal pursuit, the PETT conducted in darkness may have different pathognomic significance from PETT conducted with an illuminated background.

Part II of the present report is derived from procedures described in Part I and presents further evaluation of the data collected from the sixty normal subjects.

PROCEDURE

The conditions for the visual pursuit tracking task in darkness and in dim illumination were described in Part I. The records shown in Figures 1-30 were slightly less than half of the entire record for each subject under each viewing condition. The following method was devised to compare the "goodness" of pursuit following throughout each record under the two viewing conditions. Two raters independently viewed the entire record of each subject for each condition. The sixty pairs of records were coded with a number between 1 and 60, and each member of a pair was denoted by a letter A or B. Letters were assigned to the two viewing conditions in a random fashion unknown to the raters. Each record of the pair was rated independently by each rater on a seven-point scale, with 7 signifying excellent visual pursuit tracking and 1 signifying very poor tracking. Tracings of pendulum position and of eye position were on adjacent channels of the strip chart so that accurate pursuit tracking would yield essentially parallel and identical tracings. Factors in the eye movement tracings contributing to low ratings were 1) step or staircase patterns approximating a sinusoidal curve but deviating from it because of low eye velocity intermittently compensated by corrective saccades to sustain the tracking pattern; 2) a "sawtooth" or "cogwheel" pattern sometimes resulting from a spontaneous nystagmus superimposed upon sinusoidal pursuit tracking. This may yield a sawtooth pattern in one half of the cycle, with smooth eye velocity higher than

target velocity when the pursuit is in the same direction as the nystagmus slow phase, and a step or staircase pattern in the other half of the cycle with smooth eye velocity lower than target velocity; 3) asymmetric curves without systematic saccadic correction in which eye velocity in only one direction is low; 4) sinusoidal curves with fairly high frequency triangular or cycloid deformation superimposed; and 5) erratic pursuit, with or without saccades, in which the sinusoidal pattern is disorganized. A tendency toward any of these departures from smooth sinusoidal tracking lowered ratings. Ratings were to be relatively undiminished when very good sinusoidal tracking was only occasionally interrupted by a saccade followed immediately by resumption of accurate tracking. This type of occasional discrepancy is probably attributable to brief lapses of attention to the task (20, p. 278).

RESULTS

Based upon magnitude estimates of the accuracy of visual pursuit, ratings of performance in the presence of the dim background were superior to performance in darkness in a large proportion of the paired comparisons rendered by both raters (Table I and Appendix A). However, as would be expected in data from a group of nominally healthy young men who had recently passed a physical examination, visual pursuit was typically good in both conditions; mean ratings of 5.87 and 5.07 were obtained for the dim and dark backgrounds, respectively. However, this small mean difference in ratings of the two conditions proved to be highly significant statistically, as indicated by a *t*-test ($t = 7.5$, $p < .0001$) for related measures and by nonparametric statistics as well. Because of the nature of the data a simple nonparametric statistic, the sign test corrected for continuity, was also used (21). Comparisons from data of Raters 1 and 2 (see Appendix A) yielded respective *z* statistics of 5.58 ($p < .0001$) and of 4.90 ($p < .0001$). Slight differences in pursuit under the two conditions appear to be a statistically reliable result. There was fairly good agreement between raters in these evaluations. The Spearman rank order correlations (corrected for ties) between the two raters was .67 for the dim illumination condition, and for the dark condition it was .81. The higher inter-rater correlation in the dark condition is to be expected because there was a larger range of response variation in this condition; i.e., the lower inter-rater correlation in the dim illumination condition appears attributable to a restricted range of scores. Nevertheless both correlations are highly significant statistically.

Perusal of Appendix A will reveal that in those few cases in which superior performance occurred in the dark condition, the difference was very slight. Occasionally, however, there were fairly substantial differences in which an individual's performance was clearly inferior in the dark condition. Figure 31 presents one of the most extreme examples of this latter result that we have encountered. This particular individual was not one of the sixty subjects in this study but was an "airsick referral." Despite receiving repeated reminders to sustain alertness and voluntary effort in pursuing the target, this apparently cooperative individual yielded records typified by Figure 31 throughout PETT conducted under both viewing conditions on two separate days. Occasionally, then, an apparently normal individual may yield very poor PETT records in the dark condition.

Table I

Visual Pursuit with and without Visible Background

Paired Comparisons of Recordings from Each of 60 Subjects by Two Raters

Categories	Category Count Rater 1	Rater 2	"Average" Rater
Visible Background (A) Superior	41	36	44
Dark Background (B) Superior	3	4	3
A = B	16	20	13

Total Comparisons Each Rater = 60

GENERAL DISCUSSION

The data suggest that visual pursuit of a sinusoidally moving light viewed against a stationary, dimly illuminated, striped background is superior to visual pursuit of the same moving light viewed in darkness, although alternative interpretations should also be considered:

1) It is possible that attention lapses are more frequent in the dark, especially in a test period that occurs second, as in our procedure. While it is clear, as will be discussed below, that sustained voluntary effort is important to PETT performance, we believe that inequality in effort was not an important determiner of the differences observed between viewing conditions. Testing under each viewing condition lasted only 60 seconds; subjects, alert, intelligent, and generally very cooperative young men, were specifically instructed before and between test periods to maintain a sustained voluntary effort, and they received brief reminders within test periods whenever several response cycles appeared deviant. Moreover, twenty additional subjects tested with the order reversed have yielded the same result; i.e., tracking in dim illumination was slightly superior to tracking in darkness.

2) The dull black pendulum shaft, though almost imperceptible in the dim illumination, nevertheless may have provided an additional motion cue that contributed to improved tracking. While we cannot with certainty discard this possibility, we do not believe that it was a significant determiner of our findings. Robinson (18, p. 404) has indicated that there is little difference between man's ability to track a small target on a blank background and to track the same target with a striped background attached to it. This suggests that visibility of our pendulum shaft made little or no contribution.

Thus, with some reservations, our results support the idea suggested by Hood (13) and Hood and Leech (14) that images traversing the peripheral retina play a role in stabilizing voluntary visual pursuit of moving targets. It is important to note that voluntary effort to track and hold a selected target is important to visual performance whenever there is motion in the visual field, and it is important to our results in particular. In our dim illumination condition, any normal subject would be able to fixate any discernible part of the background and completely suppress pendular eye tracking, if he chose to do so (19). Similarly, in the experiment of Benson and Cline (3) in which subjects on a turntable were oscillated at a low sinusoidal frequency while viewing a head-fixed target, fixation of the target requiring suppression of vestibular nystagmus seemed to be enhanced by peripheral view of the moving (relative to the subject) surrounds. However, these subjects could have chosen to view the dimly illuminated surrounds external to the rotation device, and had they done so, vestibular nystagmus would have been augmented rather than suppressed by the available optokinetic stimuli. Consider further a situation in which a distinctly visible small selected target is stationary (target and observer are Earth-fixed) while there is uniform motion in the surrounding peripheral visual field. Fixation of the target can be sustained (19, p. 25), and the direction of peripheral field motion, e.g., right or left, is probably irrelevant to the degree of oculomotor control. The observer, after a few seconds, will probably feel he is turning in a direction opposite that of the moving visual field (4,8,9), but even so, the target is perceived as head-fixed (which it is), and hence there is no voluntary command for oculomotor pursuit of a moving target. With successful fixation an absence of foveal slippage and a uniform movement over the peripheral retina are consistent with the voluntary command in relation to the perceived state of motion of the target relative to the body. A different situation exists during visual pursuit of a moving object. If the eye successfully tracks the target, then again there is little or no foveal slippage and again there is a tracing of images over the peripheral retina, but now the direction of background movement may be quite important to oculomotor control; i.e., the slippage on the peripheral retina may serve to stabilize eye speed relative to target velocity when the direction of the peripheral slippage is consistent with that peripheral slippage preprogrammed (fed forward) by the intended direction of the voluntary eye movement. Thus peripheral slippage may supplement foveal slippage as a source of oculomotor control. This would mean that during eye rotation to track a rightward-moving target, a counterclockwise movement over the peripheral retina would enhance oculomotor control and that during eye rotation to track a leftward-moving target, clockwise peripheral image movement would enhance control. Consistent with this interpretation, aside from our results, are some additional observations by Hood (13) who found that stripes on a small optokinetic drum moving in a direction opposite that of a large striped background were more clearly visible than when the drum stripes and background stripes moved in the same direction. Whatever the mechanism of these effects, a similar mechanism may be involved in the effects reported by Benson and Cline and in more recent experiments (12) showing that the direction of background movement is crucial to the ability to sustain voluntary fixation of a head-fixed target during strong vestibular stimulation. It appears that motion of images over the peripheral retina can enhance voluntary visual pursuit of a moving target (and possibly motion in the 'wrong' direction can degrade it) and that peripheral field motion

can either enhance or degrade visual suppression of vestibular nystagmus depending upon the concordance or discordance of the vestibular and peripheral optokinetic inputs (12).

A result that possibly might be at variance with our findings was reported by Hood (13). He found in normal subjects little or no difference in visual pursuit tracking with and without a visible striped background in "preliminary experiments" although he did find marked differences in cerebellar patients under the two conditions. If we assume that "preliminary experiments" signifies only a few observations with normal subjects, then Hood's results are not necessarily disparate with our observations which included a number of normal subjects exhibiting either slight differences or no differences between viewing conditions. If, however, the results are truly disparate, then several procedural differences may be pertinent. Hood employed a cyclic waveform that was triangular with a period of approximately 5.3 seconds and a peak-to-peak displacement of about 45 degrees. This means that a constant eye velocity of less than 20 deg/sec was sufficient to track his moving stimulus. Our stimulus was sinusoidal in form with a 2-second period. In the first cycle of our stimulus the peak angular velocity was slightly over 60 deg/sec, near the upper limit sometimes indicated (2,22) for accurate visual pursuit, and after 60 seconds of pendulum motion peak velocity had diminished but it was still almost 30 deg/sec as the test ended. Thus the peak tracking velocities and the continuous change in velocity in our sinusoidal waveform probably constituted a greater challenge to visual pursuit than did the stimulus employed by Hood.

Several authors have referred to "little or no" difference in visual pursuit under different viewing conditions, but in the present study slight differences occurred sufficiently often in a given direction to suggest statistical reliability. Thus "little or no" difference may sometimes be a significant difference. Our scoring procedures resembled those in use clinically except that the rating system provided at least an ordinal measurement scale and comparison. While the method seemed sufficient to reveal the slight differences in our results, a more objective and quantitative approach would certainly be desirable. A fairly simple record analysis in the time domain would seem a reasonable approach (report in preparation). Simple measurement of eye velocity relative to target velocity could provide gain ratios, directional differences in gain, and phase angle limits for normal subjects. These measures together with simple counts of saccades (by direction) in each half cycle would probably be sufficient to characterize quantitatively most pathognomic patterns of systematic deviation from normal responses. A promising alternative involving Fourier analysis in the frequency domain has been suggested by Correia (6).

CONCLUSIONS

Pendular eye tracking tests conducted with and without visible backgrounds yield different ranges of variation in response among normal subjects, at least when conducted under our stimulus conditions. Moreover, dynamic stimulation of the peripheral retina during PETT involves some central nervous system processing that probably is not involved in a PETT conducted in darkness. Thus the two procedures may have different pathognomic significance. This appears to be supported by Hood who, as just noted, found

little difference in results between two viewing conditions (very similar to ours) in normal subjects but "striking differences" between viewing conditions in patients with cerebellar lesions, visual pursuit being deranged in the presence of visible background. This finding seems particularly important, assuming that it can be further substantiated, since it was with a visible background that our normal subjects yielded superior visual pursuit. We tentatively conclude that the PETT should be conducted under both conditions, i.e., with and without visible background, and that quantitative time-domain analysis of the oculomotor response relative to the sinusoidal stimulus will be sufficient to quantitatively characterize a normal range of responses and to discriminate various significant pathognomic patterns of deviation from this range.

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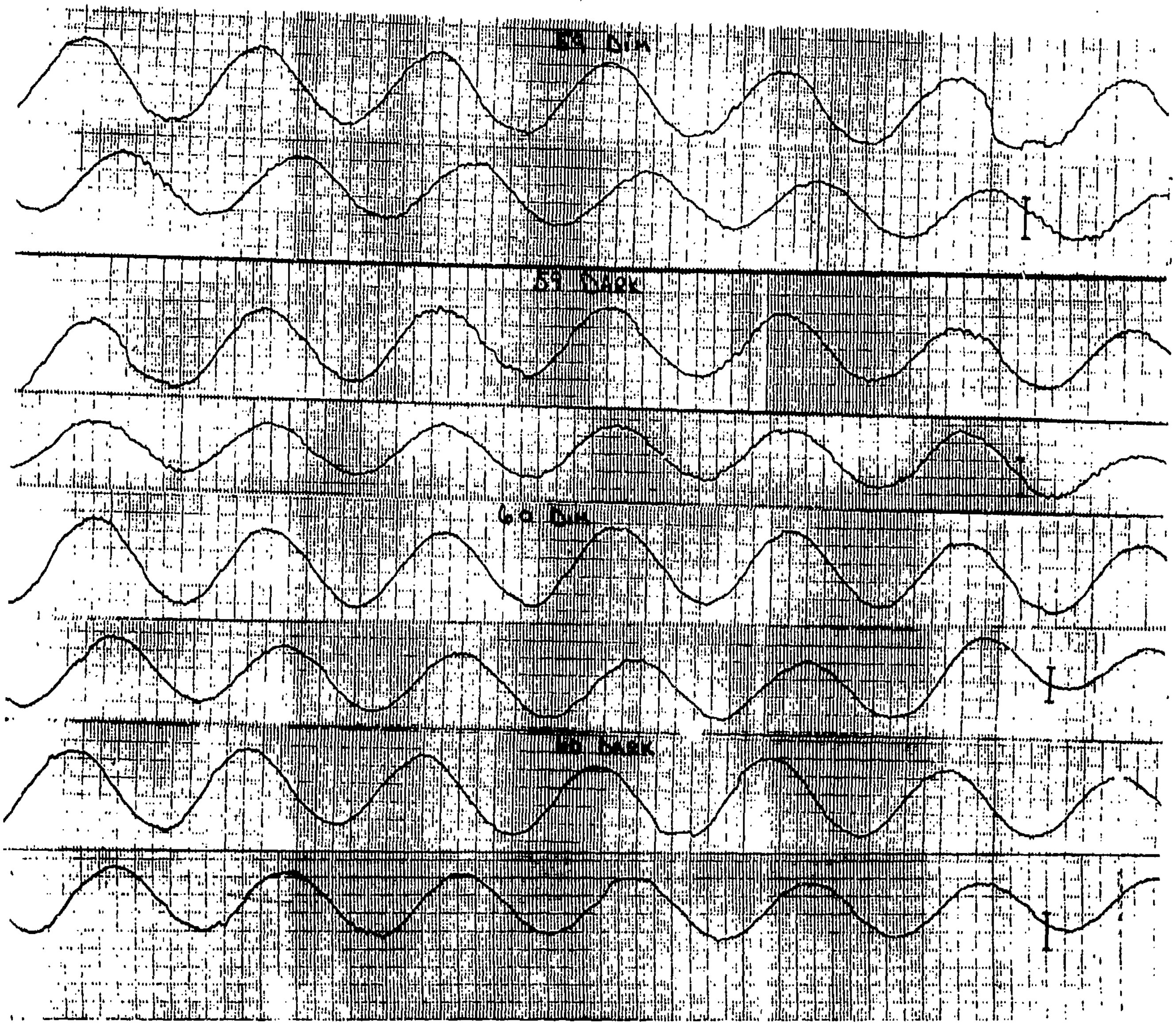

Figure 1

Pendular Eye Tracking Records from Two Individuals under the Two Viewing Conditions. Calibrations (vertical markers) indicate ±10-degree horizontal eye displacement. Each major horizontal division of reco.d grid is 0.2 second.

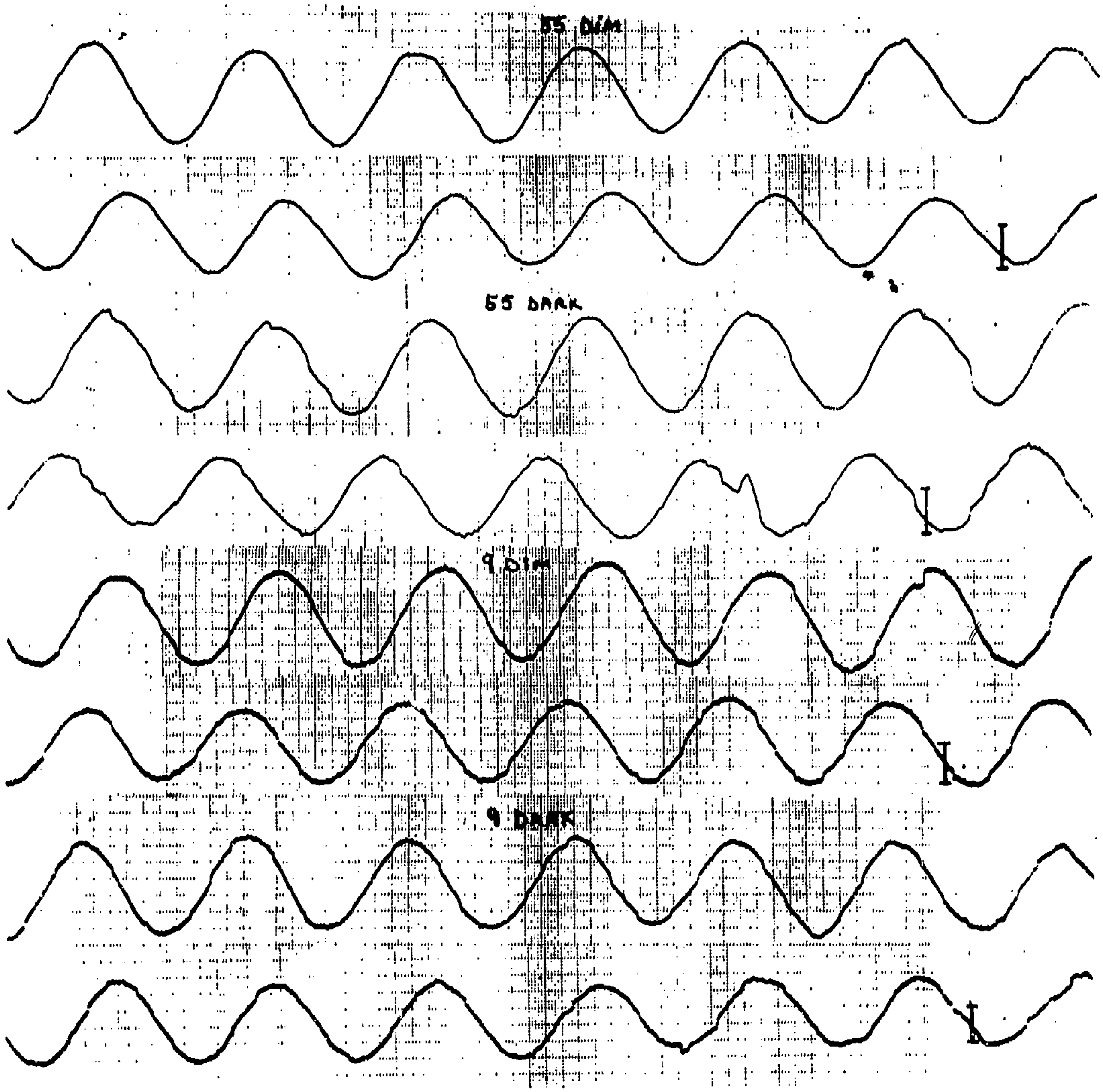

Figure 2

Pendular Eye Tracking Records from Two Individuals under the Two Viewing Conditions. Calibrations (vertical markers) indicate ±10-degree horizontal eye displacement. Each major horizontal division of record grid is 0.2 second.

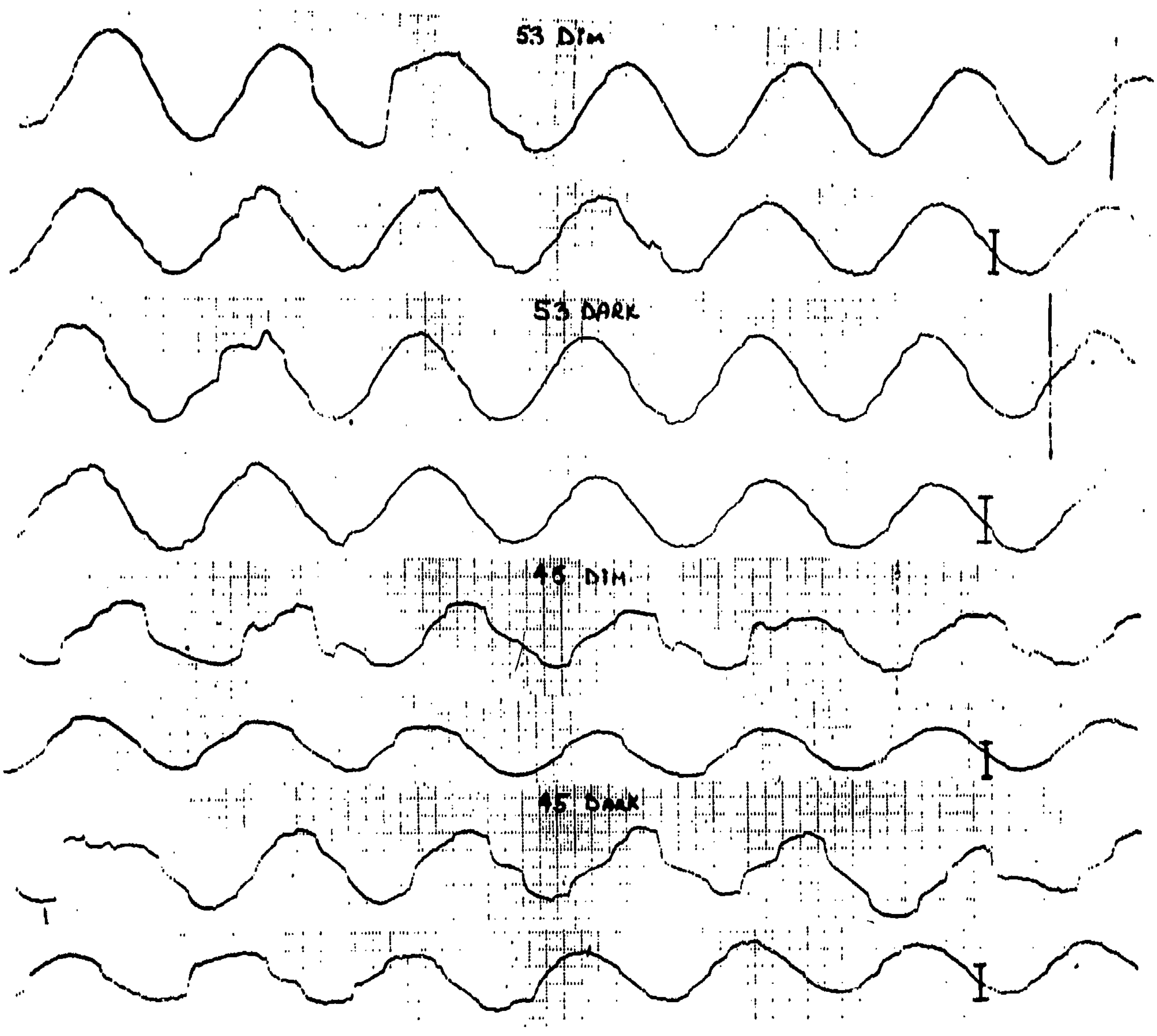

Figure 3

Pendular Eye Tracking Records from Two Individuals under the Two Viewing Conditions. Calibrations (vertical markers) indicate ±10-degree horizontal eye displacement. Each major horizontal division of record grid is 0.2 second. The stepping pattern in the records of Subject 45 is sufficiently consistent to recommend retesting with additional emphasis on voluntary effort to sustain good tracking.

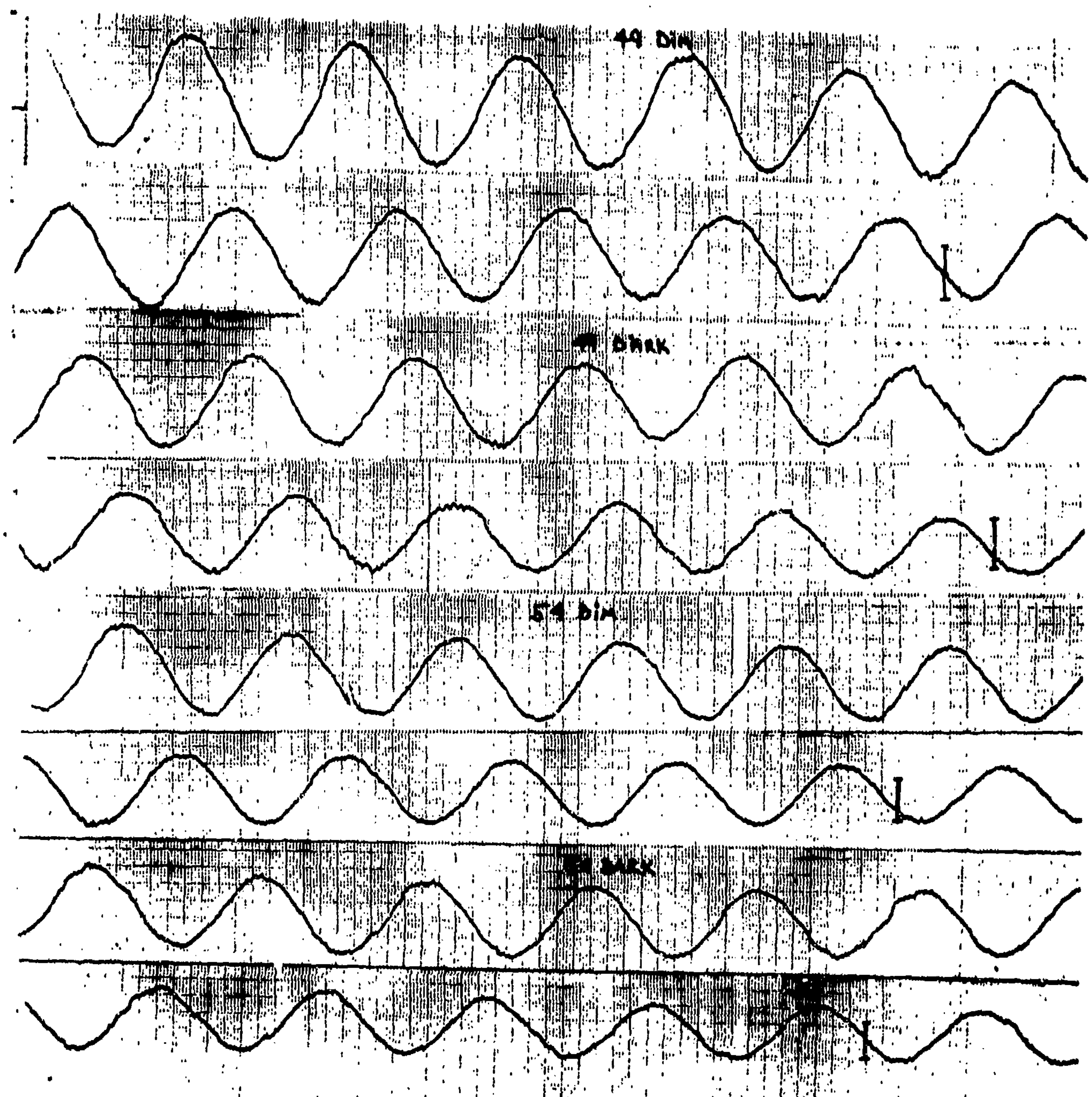

Figure 4

Pendular Eye Tracking Records from Two Individuals under the Two Viewing Conditions. Calibrations (vertical markers) indicate ±10-degree horizontal eye displacement. Each major horizontal division of record grid is 0.2 second.

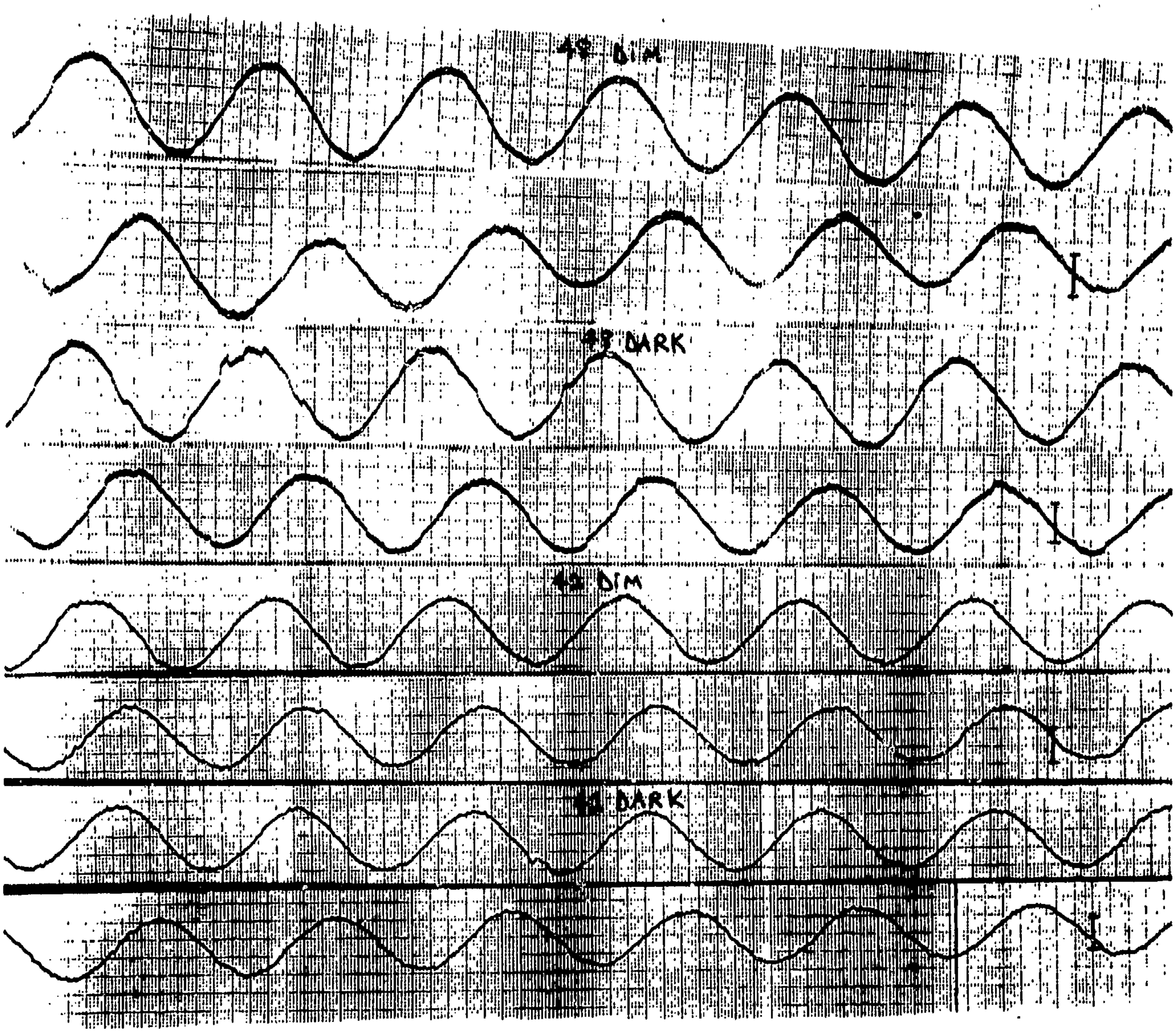

Figure 5

Pendular Eye Tracking Records from Two Individuals under the Two Viewing Conditions. Calibrations (vertical markers) indicate ±10-degree horizontal eye displacement. Each major horizontal division of record grid is 0.2 second.

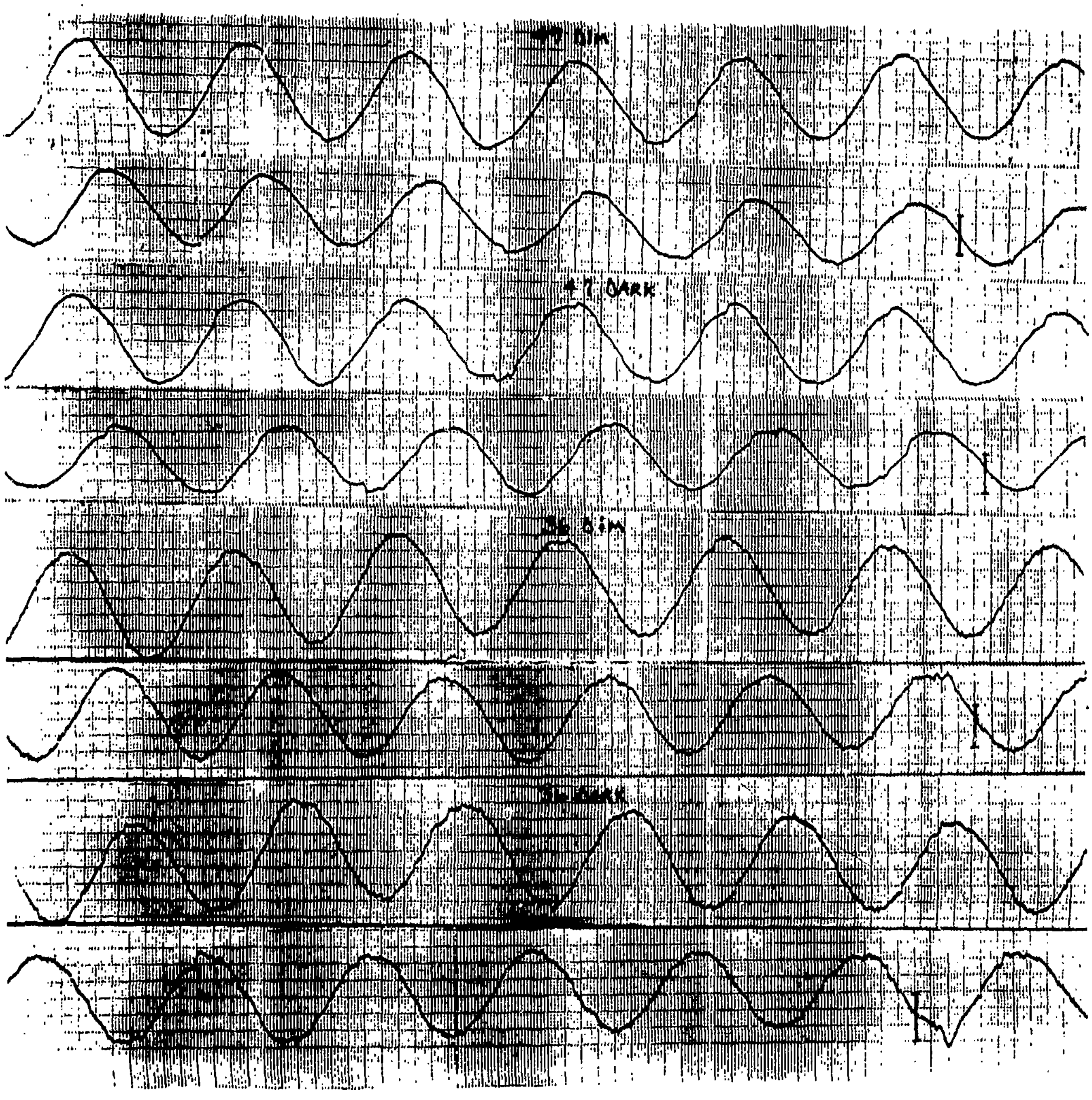

Figure 6

Pendular Eye Tracking Records from Two Individuals under the Two Viewing Conditions. Calibrations (vertical markers) indicate ±10-degree horizontal eye displacement. Each major horizontal division of record grid is 0.2 second.

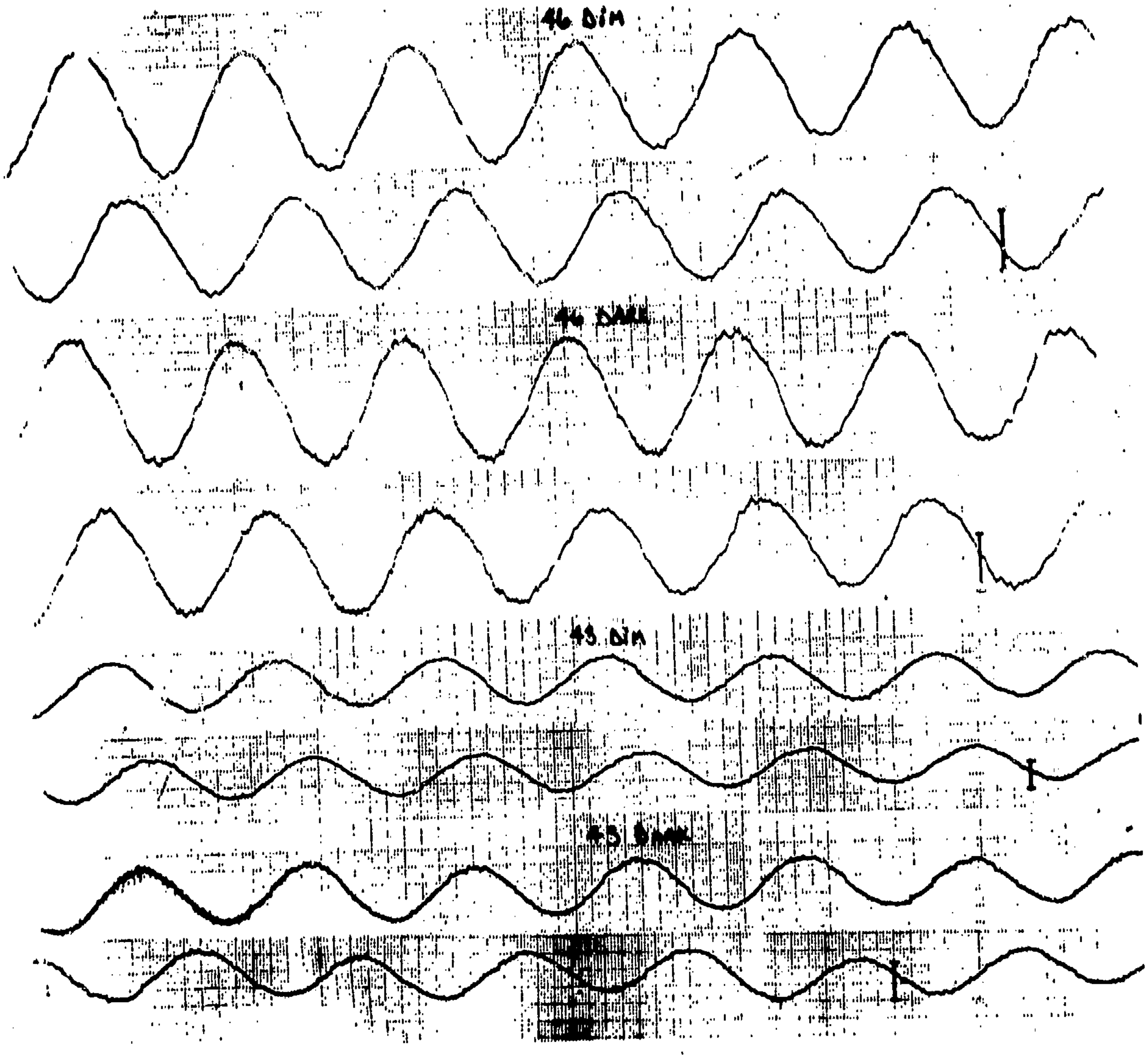

Figure 7

Pendular Eye Tracking Records from Two Individuals under the Two Viewing Conditions. Calibrations (vertical markers) indicate ±10-degree horizontal eye displacement. Each major horizontal division of record grid is 0.2 second.

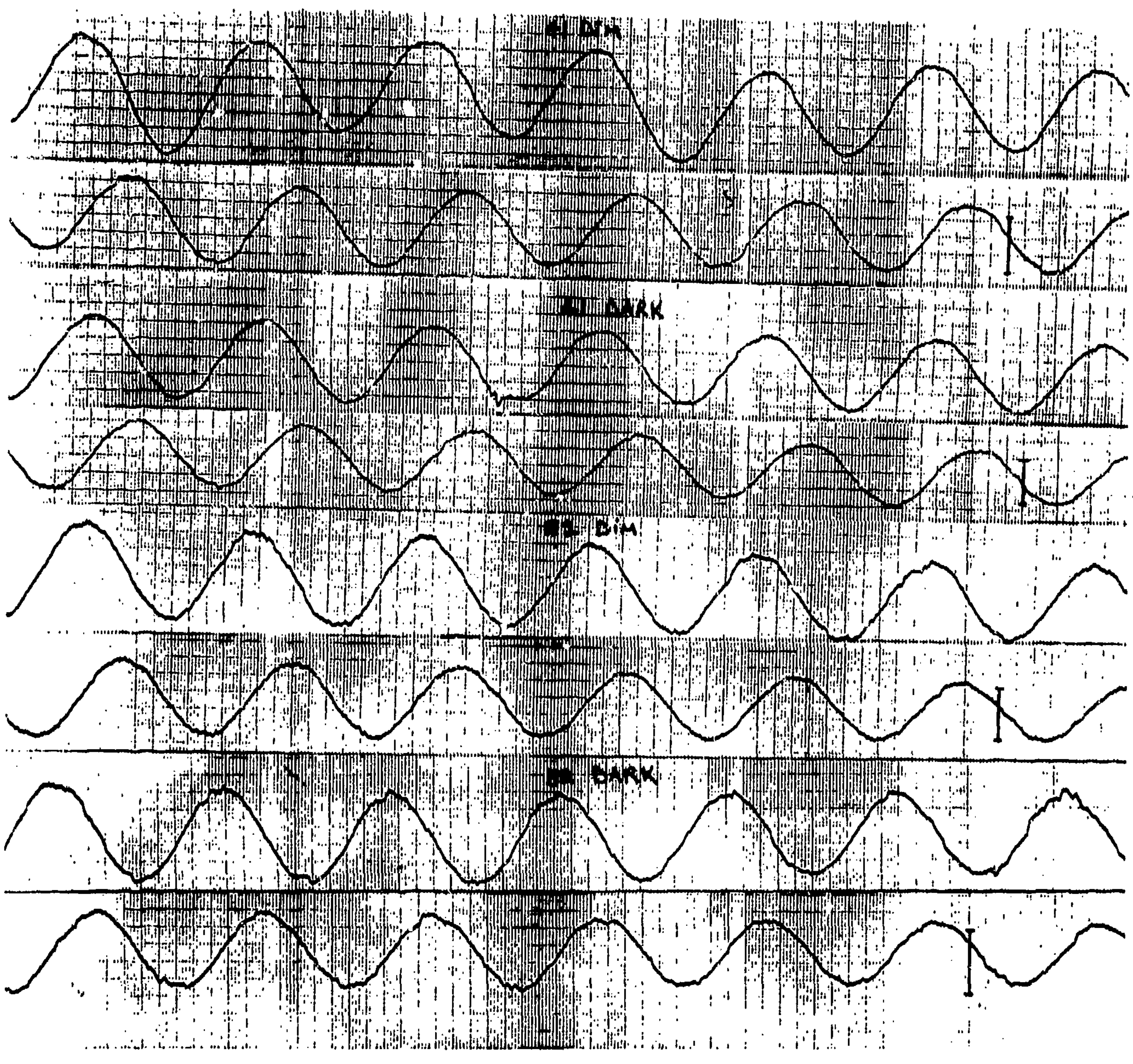

Figure 8

Pendular Eye Tracking Records from Two Individuals under the Two Viewing Conditions. Calibrations (vertical markers) indicate ±10-degree horizontal eye displacement. Each major horizontal division of record grid is 0.2 second.

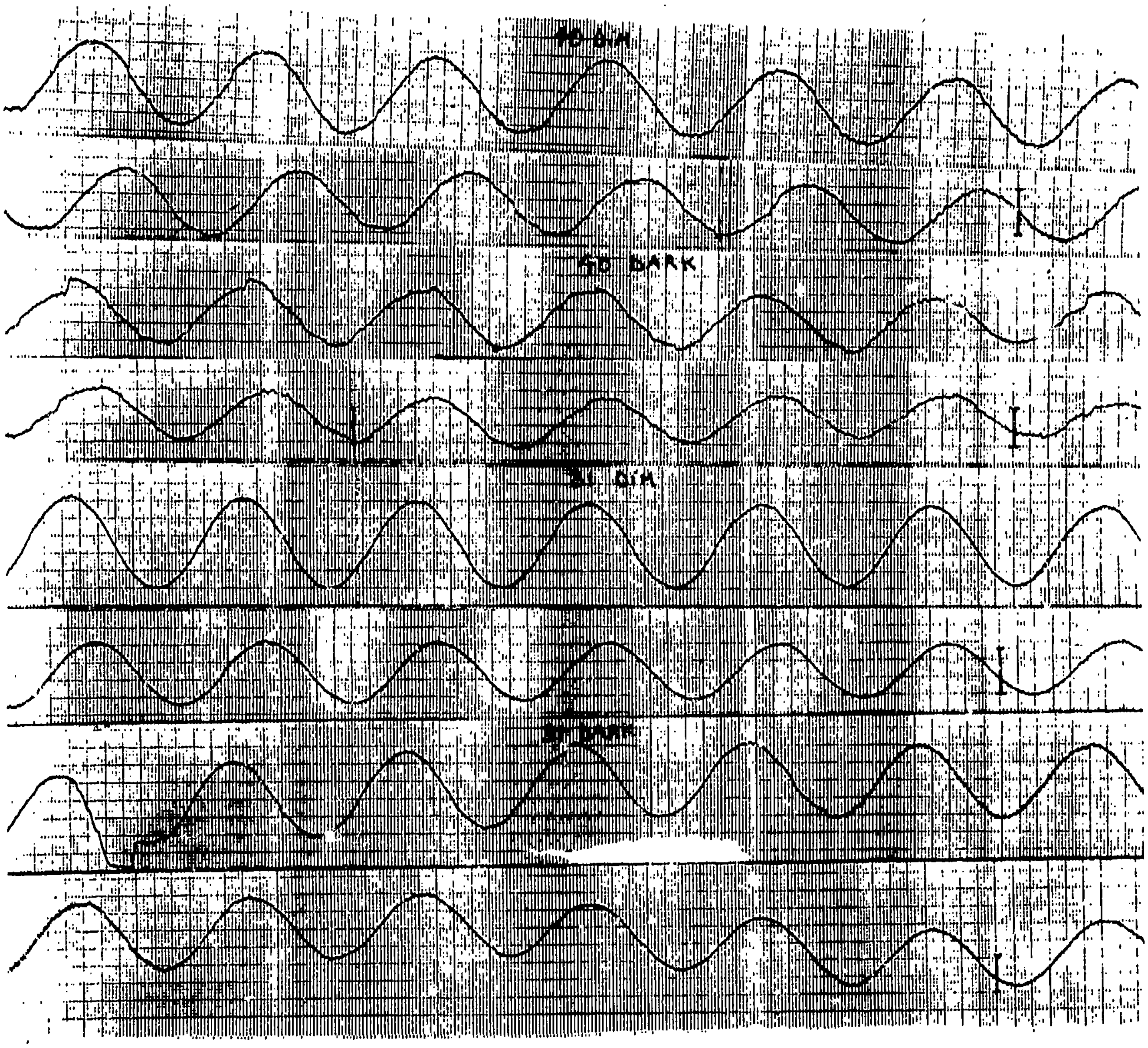

Figure 9

Pendular Eye Tracking Records from Two Individuals under the Two Viewing Conditions. Calibrations (vertical markers) indicate ±10-degree horizontal eye displacement. Each major horizontal division of record grid is 0.2 second.

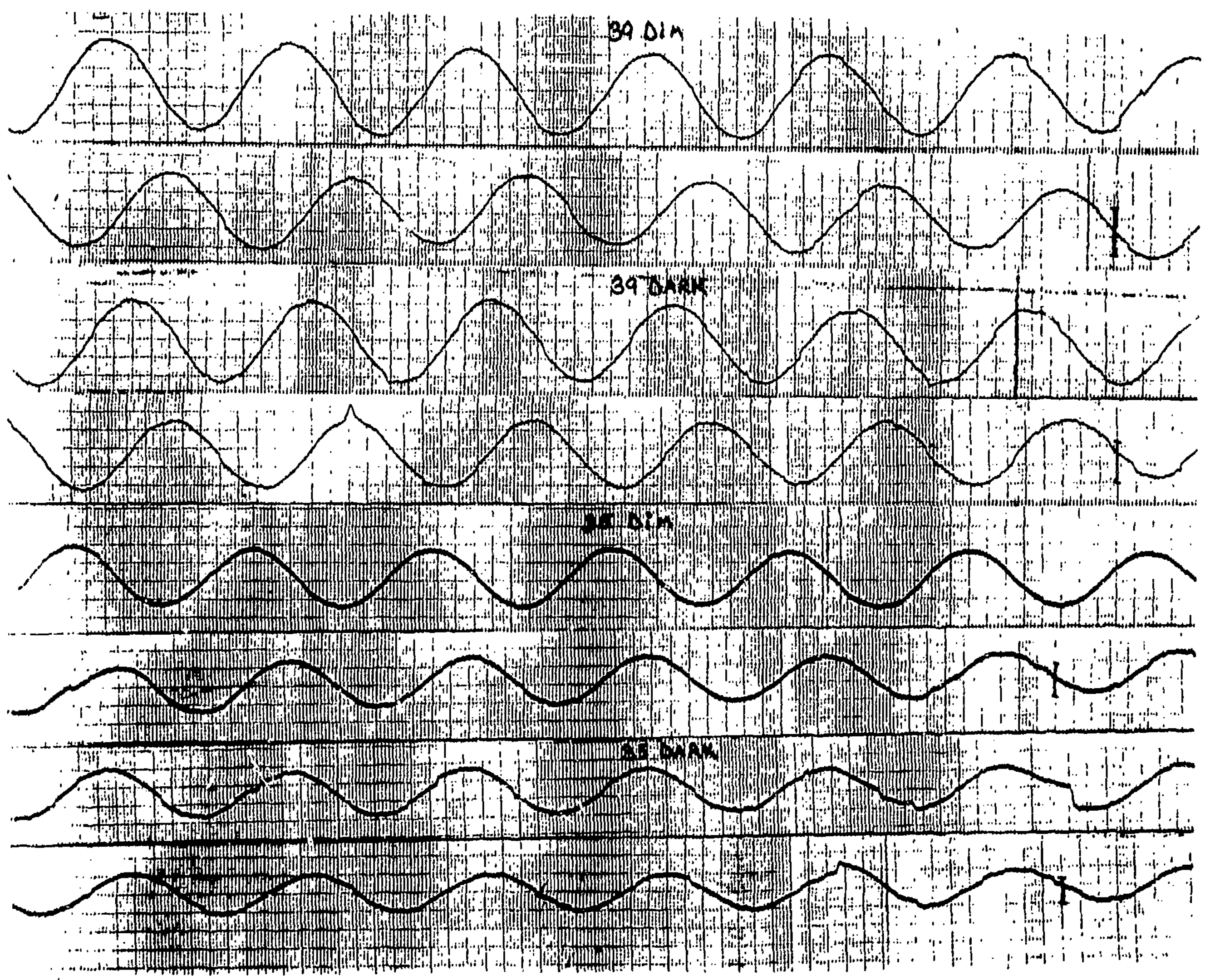

Figure 10

Pendular Eye Tracking Records from Two Individuals under the Two Viewing Conditions. Calibrations (vertical markers) indicate ±10-degree horizontal eye displacement. Each major horizontal division of record grid is 0.2 second.

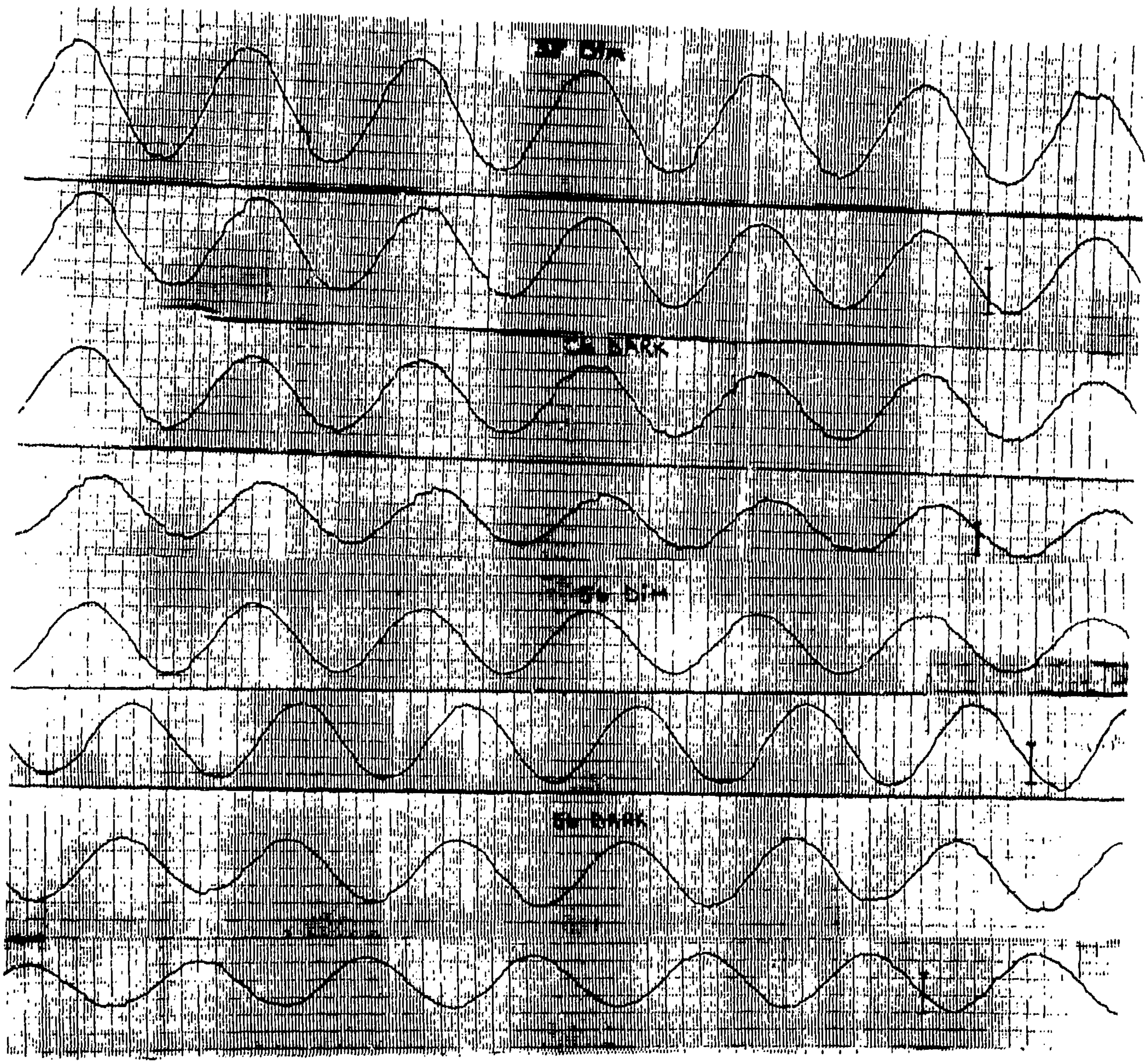

Figure 11

Pendular Eye Tracking Records from Two Individuals under the Two Viewing Conditions. Calibrations (vertical markers) indicate ±10-degree horizontal eye displacement. Each major horizontal division of record grid is 0.2 second.

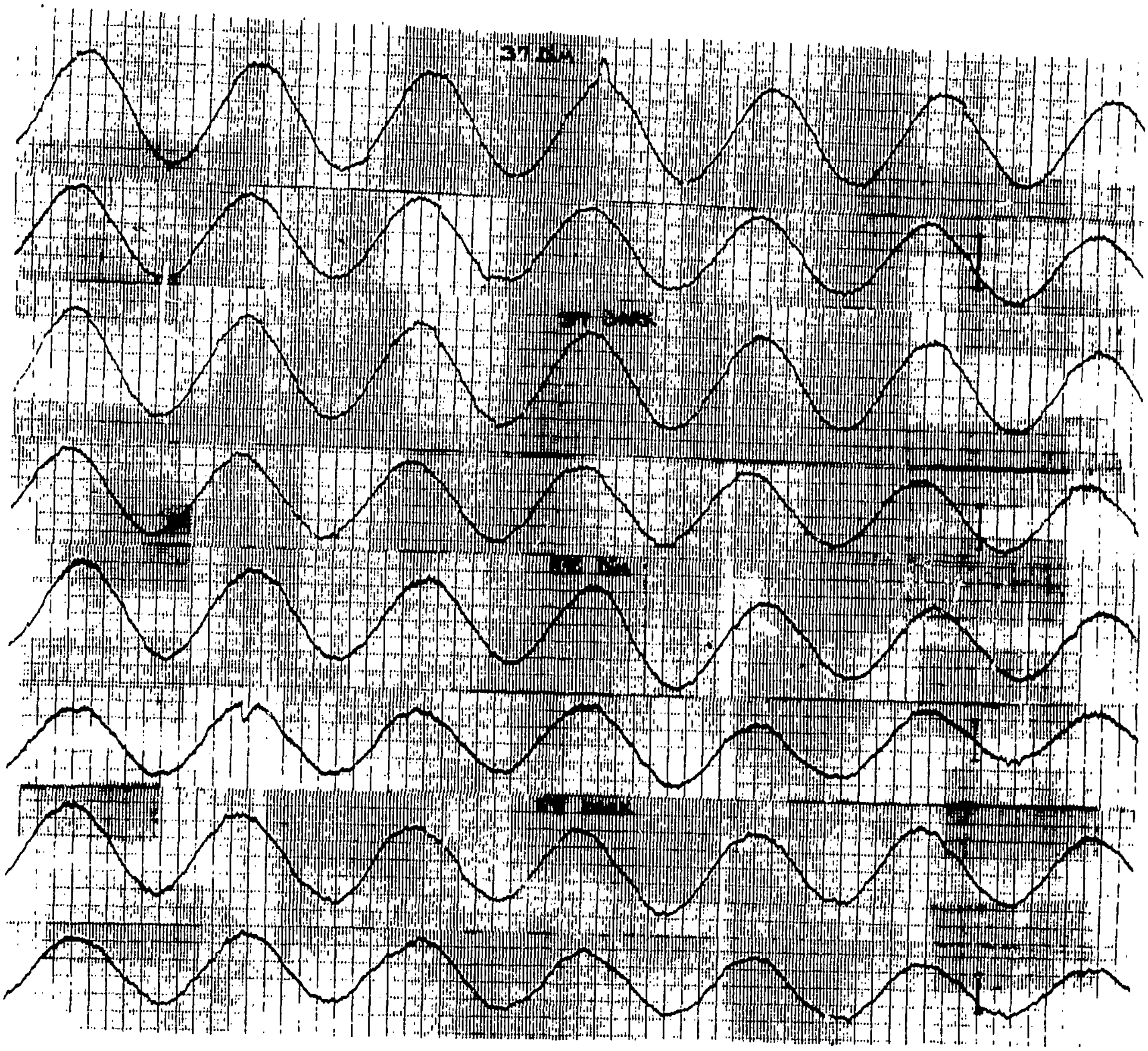

Figure 12

Pendular Eye Tracking Records from Two Individuals under the Two Viewing Conditions. Calibrations (vertical markers) indicate ±10-degree horizontal eye displacement. Each major horizontal division of record grid is 0.2 second.

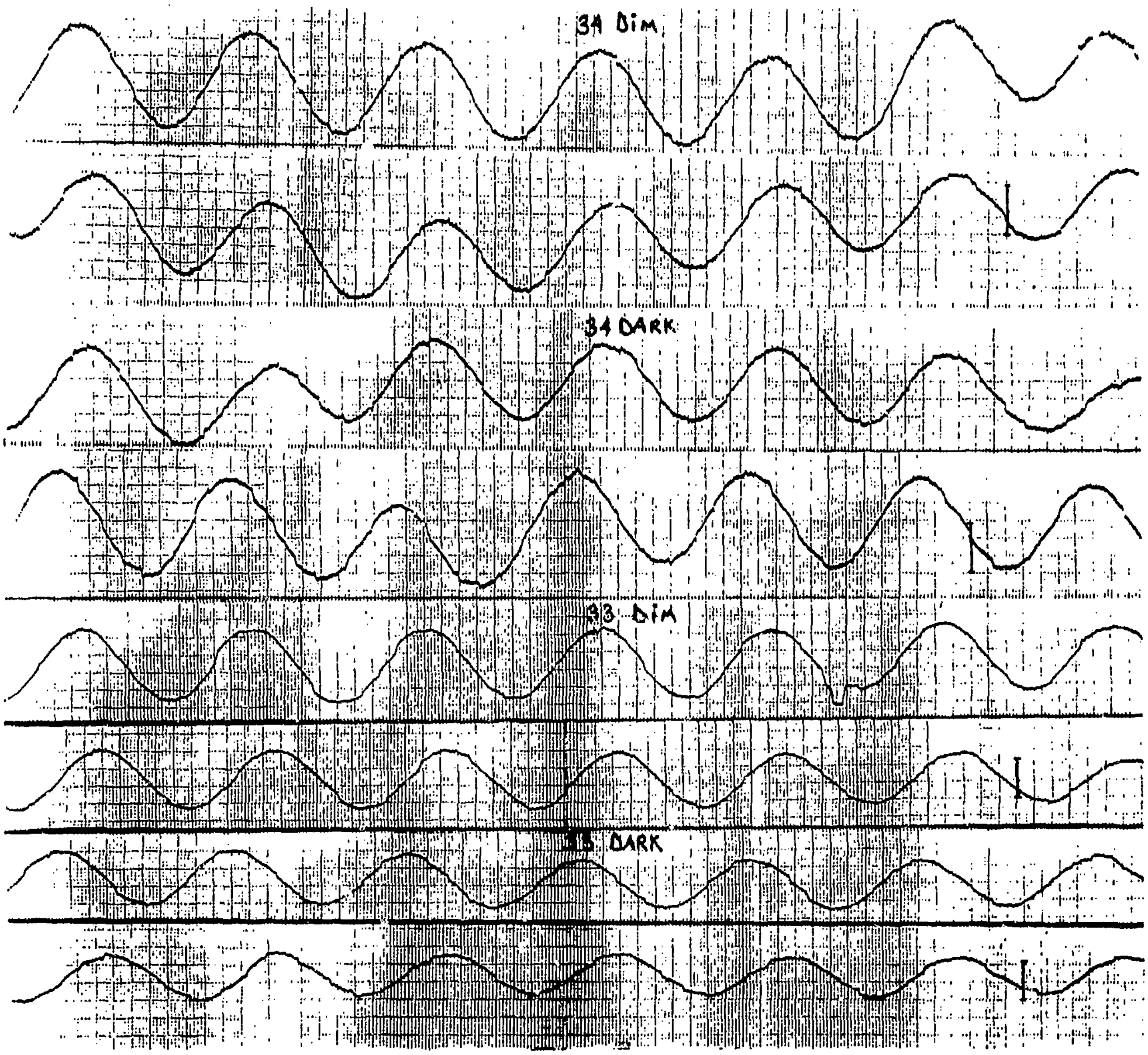

Figure 13

Pendular Eye Tracking Records from Two Individuals under the Two Viewing Conditions. Calibrations (vertical markers) indicate ±10-degree horizontal eye displacement. Each major horizontal division of record grid is 0.2 second.

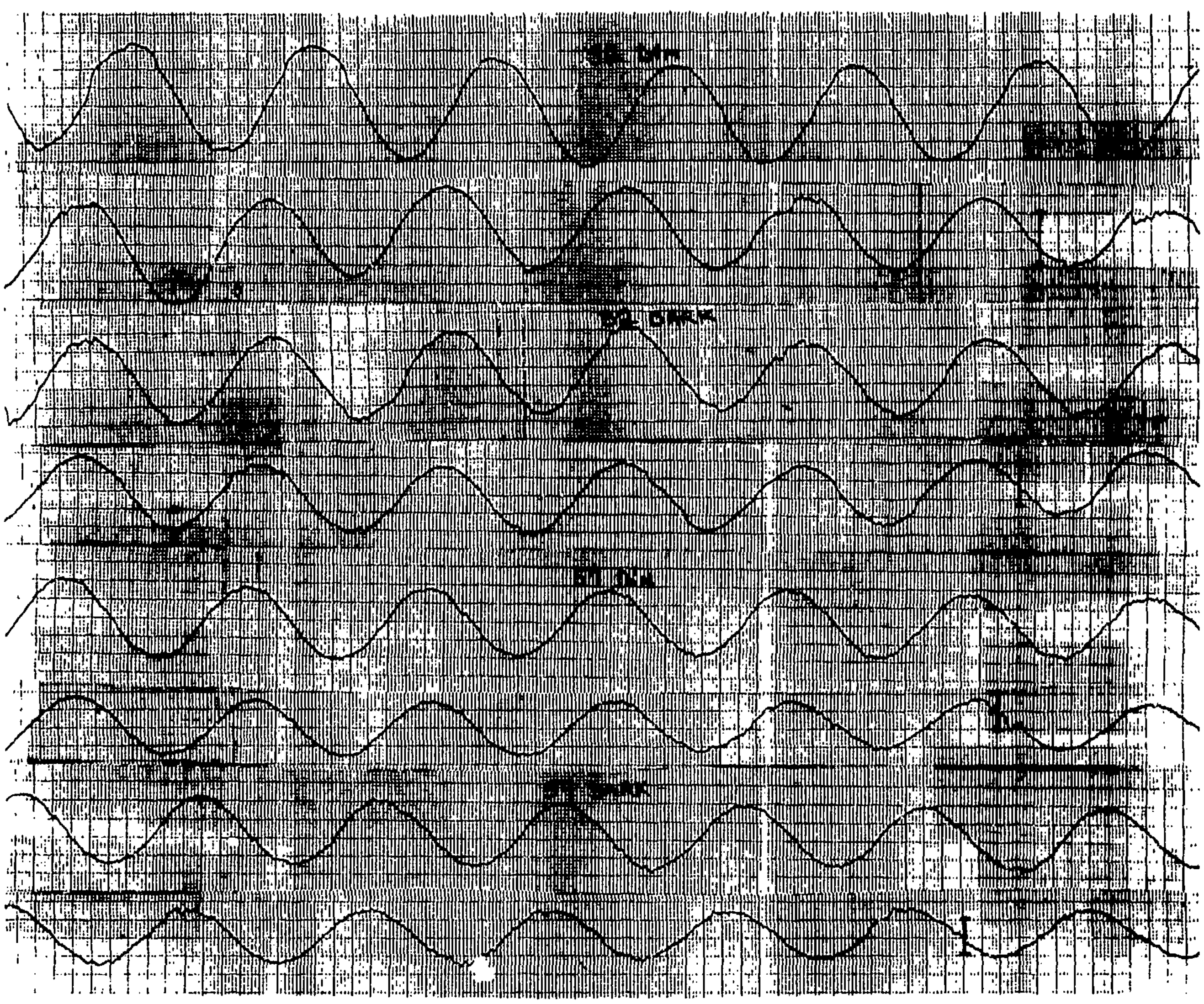

Figure 14

Pendular Eye Tracking Records from Two Individuals under the Two Viewing Conditions. Calibrations (vertical markers) indicate ±10-degree horizontal eye displacement. Each major horizontal division of record grid is 0.2 second.

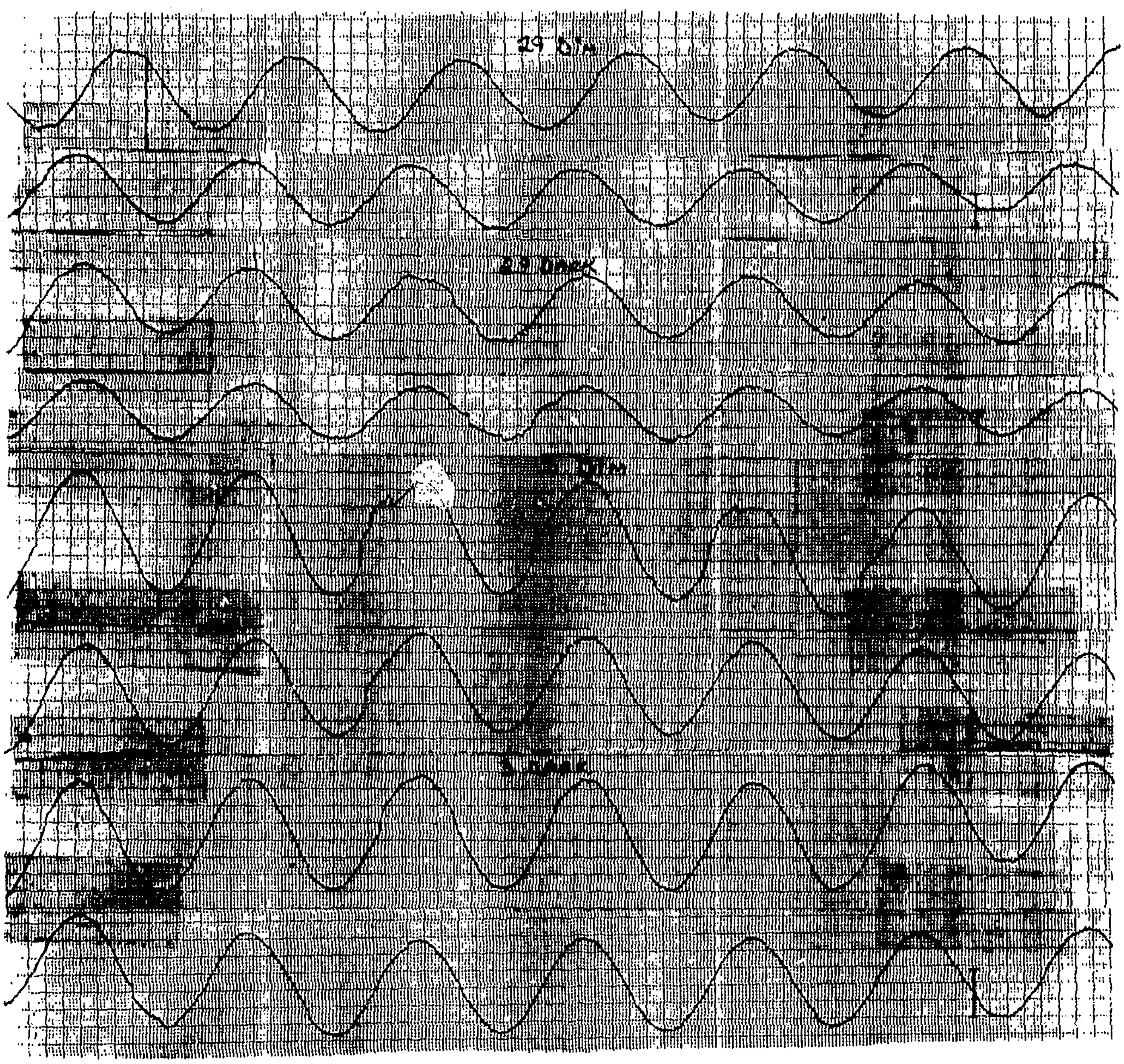

Figure 15

Pendular Eye Tracking Records from Two Individuals under the Two Viewing Conditions. Calibrations (vertical markers) indicate ±10-degree horizontal eye displacement. Each major horizontal division of record grid is 0.2 second.

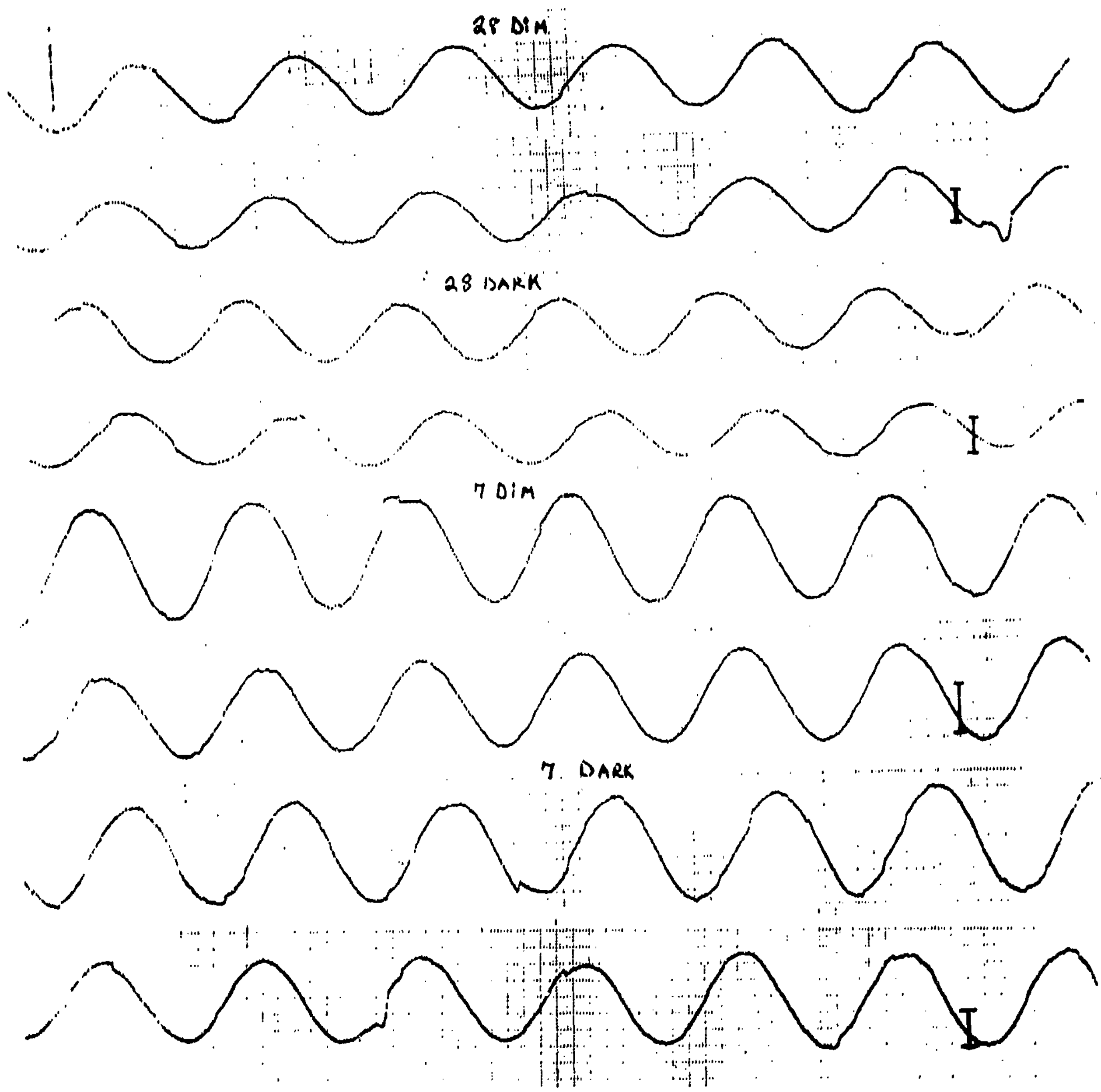

Figure 16

Pendular Eye Tracking Records from Two Individuals under the Two Viewing Conditions. Calibrations (vertical markers) indicate ±10-degree horizontal eye displacement. Each major horizontal division of record grid is 0.2 second.

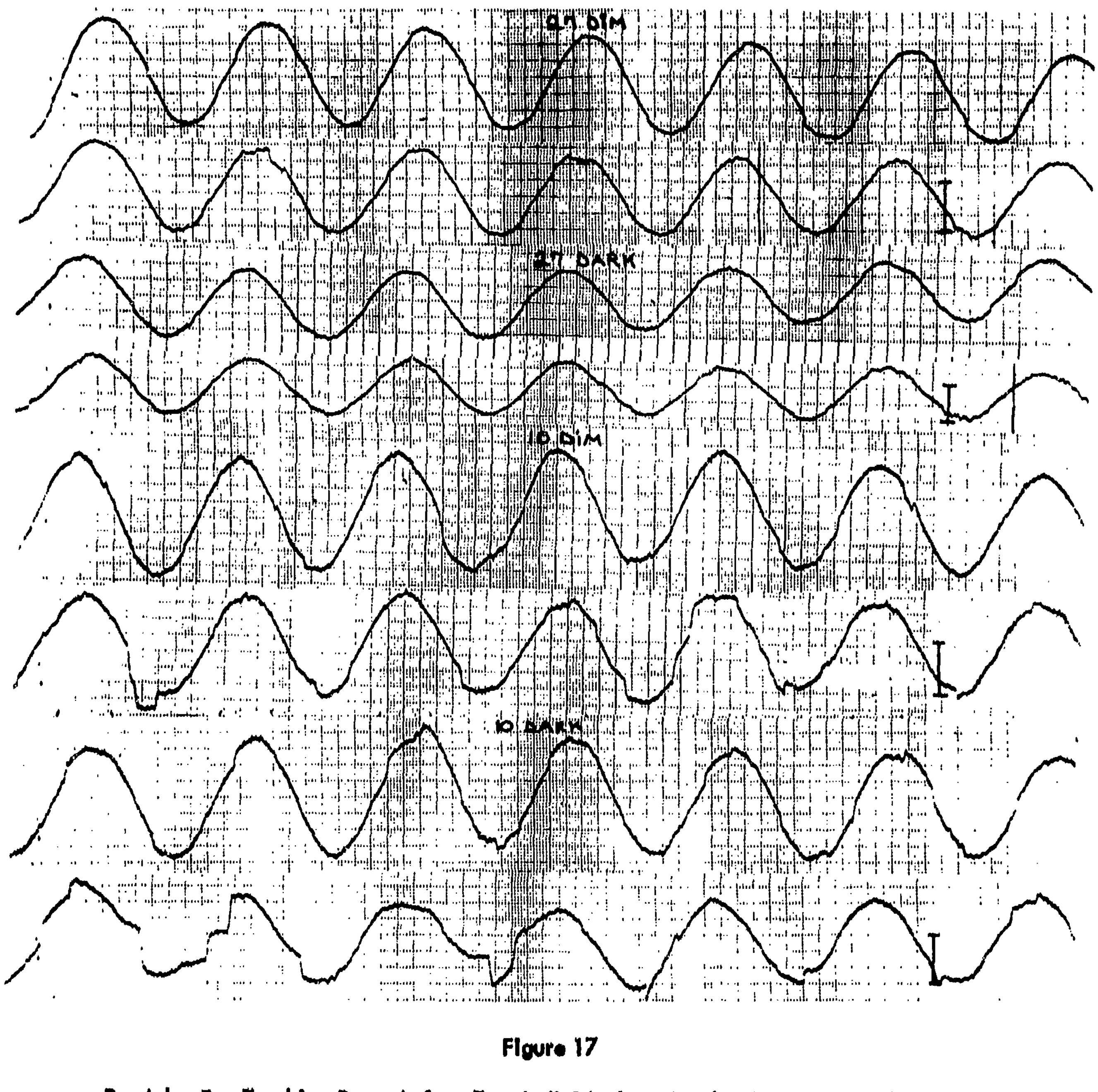

Figure 17

Pendular Eye Tracking Records from Two Individuals under the Two Viewing Conditions. Calibrations (vertical markers) indicate ±10-degree horizontal eye displacement. Each major horizontal division of record grid is 0.2 second.

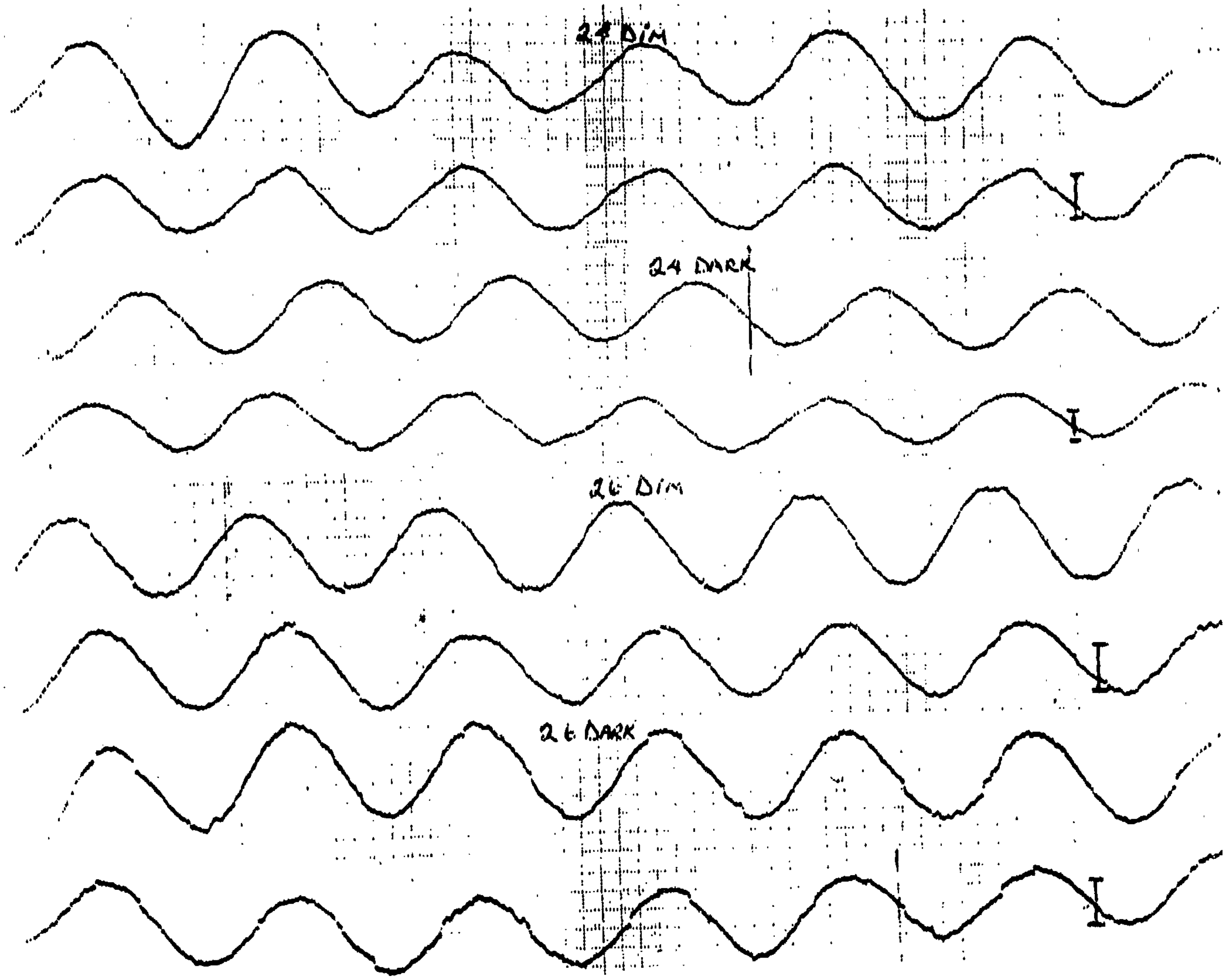

Figure 18

Pendular Eye Tracking Records from Two Individuals under the Two Viewing Conditions. Calibrations (vertical markers) indicate ±10-degree horizontal eye displacement. Each major horizontal division of record grid is 0.2 second.

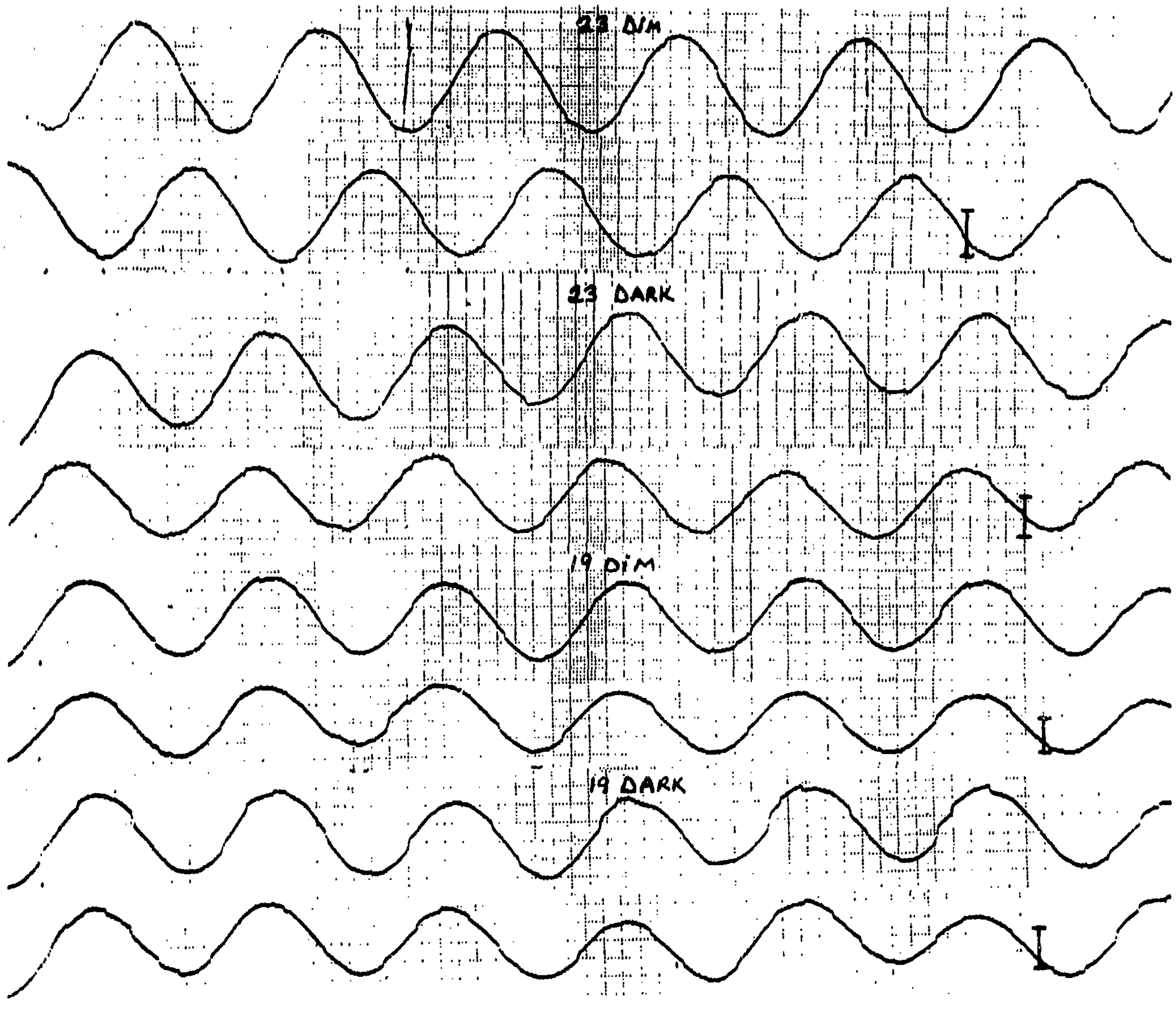

Figure 19

Pendular Eye Tracking Records from Two Individuals under the Two Viewing Conditions. Calibrations (vertical markers) indicate ±10-degree horizontal eye displacement. Each major horizontal division of record grid is 0.2 second.

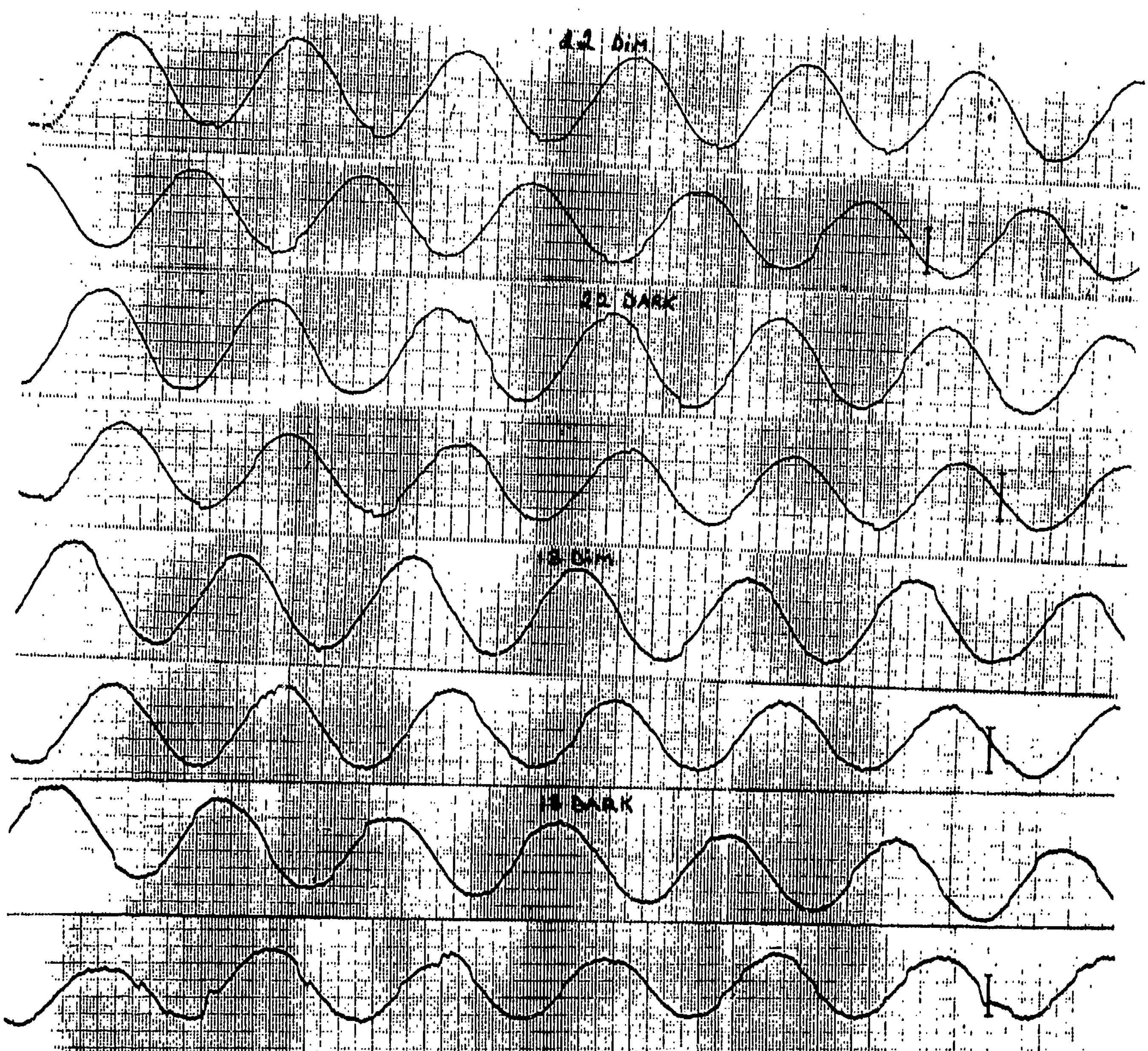

Figure 20

Pendular Eye Tracking Records from Two Individuals under the Two Viewing Conditions. Calibrations (vertical markers) indicate ±10-degree horizontal eye displacement. Each major horizontal division of record grid is 0.2 second.

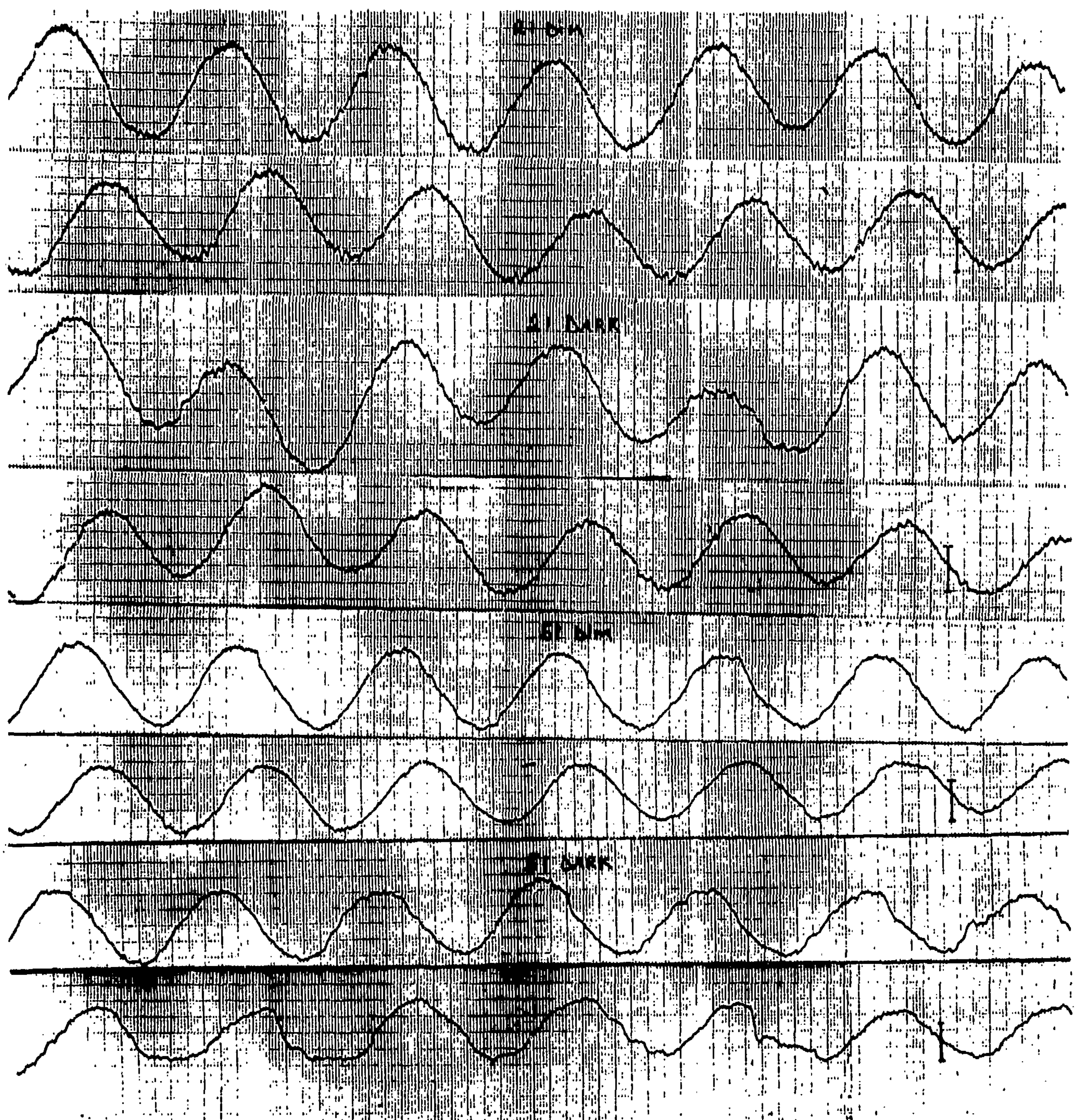

Figure 21

Pendular Eye Tracking Records from Two Individuals under the Two Viewing Conditions. Calibrations (vertical markers) indicate ±10-degree horizontal eye displacement. Each major horizontal division of record grid is 0.2 second. Irregularities noted during static-fixation recordings of Subject 21 suggest that the "cogwheel" appearance is an artifact independent of visual pursuit.

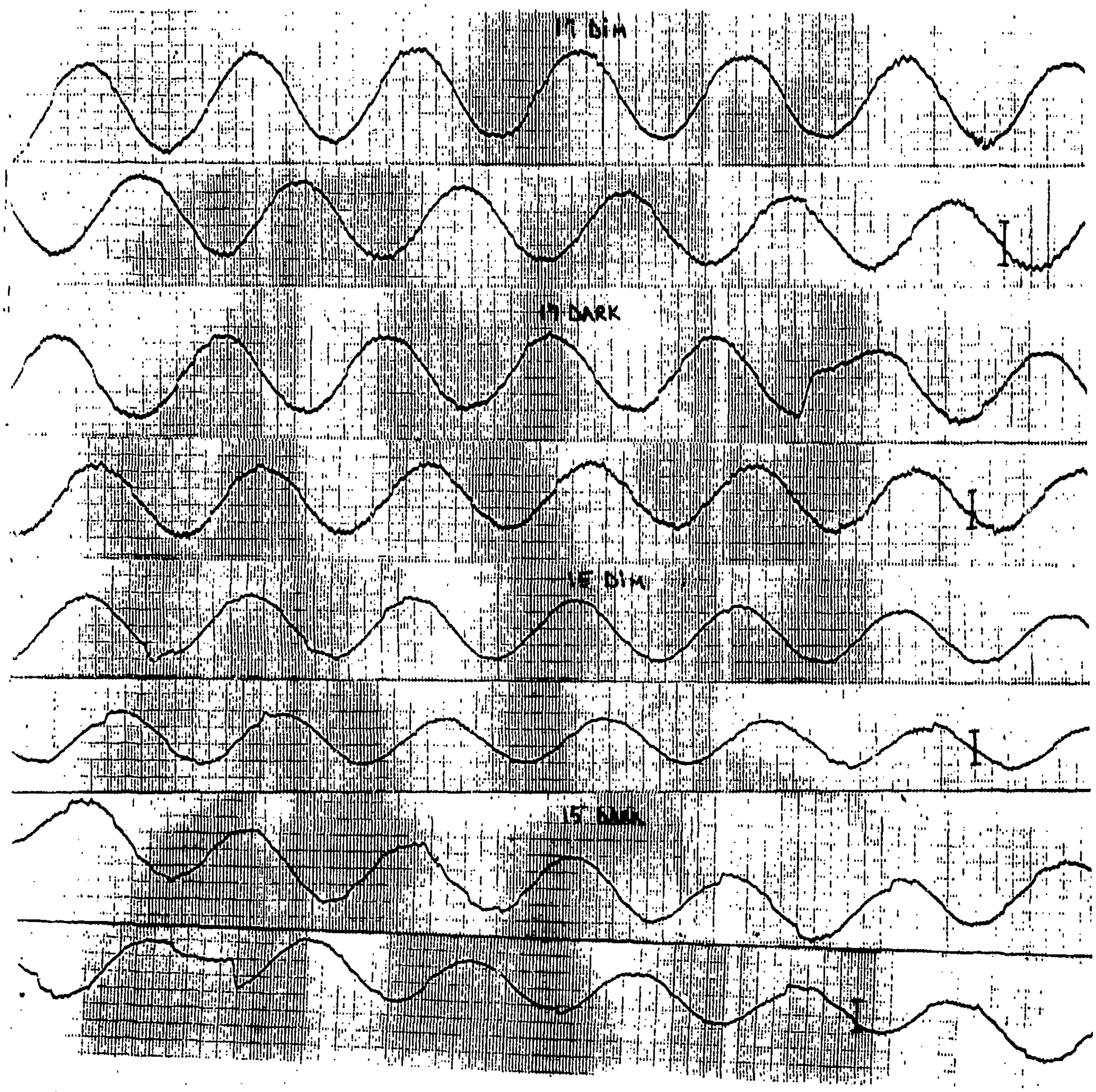

Figure 22

Pendular Eye Tracking Records from Two Individuals under the Two Viewing Conditions. Calibrations (vertical markers) indicate ±10-degree horizontal eye displacement. Each major horizontal division of record grid is 0.2 second.

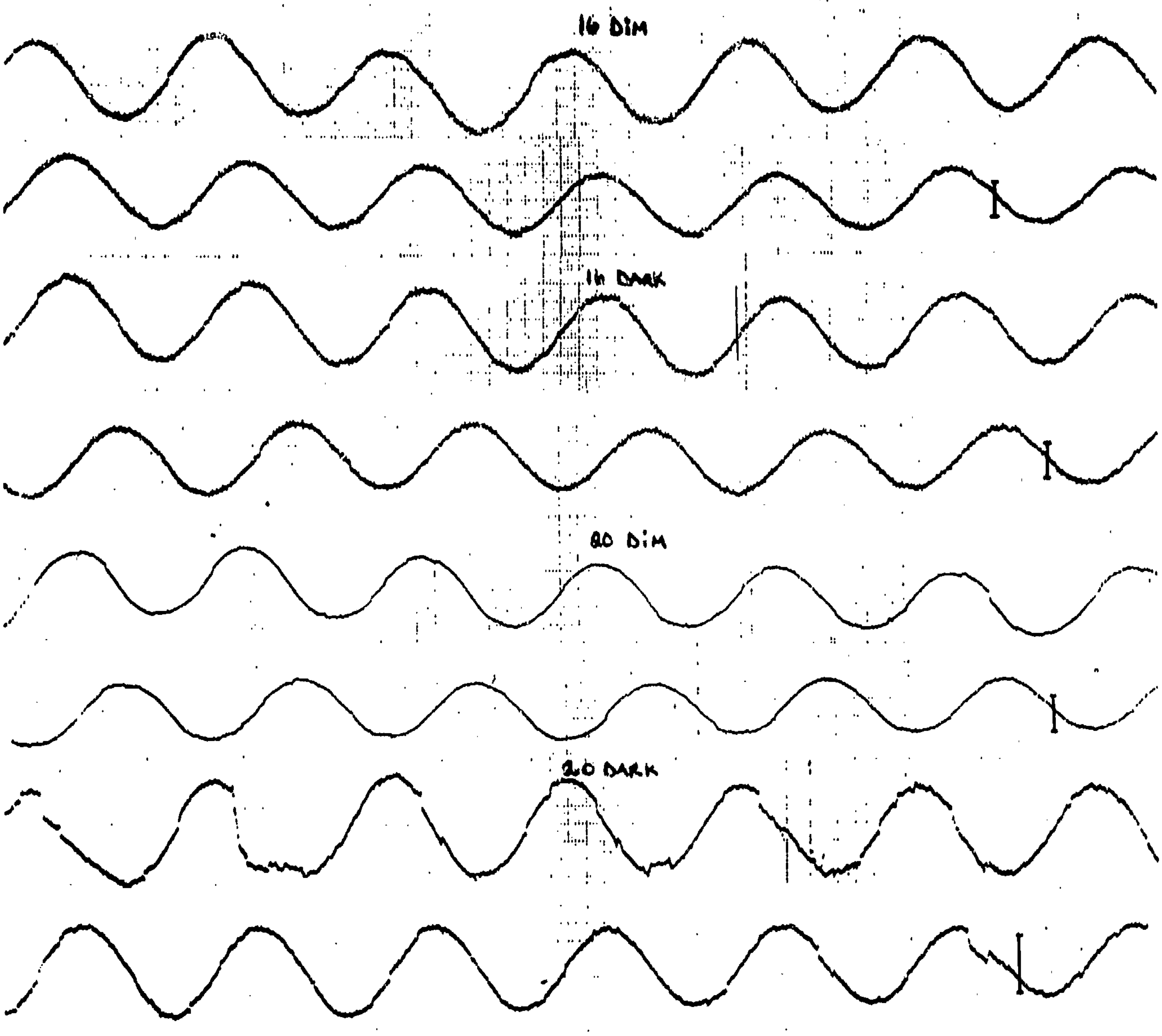

Figure 23

Pendular Eye Tracking Records from Two Individuals under the Two Viewing Conditions. Calibrations (vertical markers) indicate ±10-degree horizontal eye displacement. Each major horizontal division of record grid is 0.2 second.

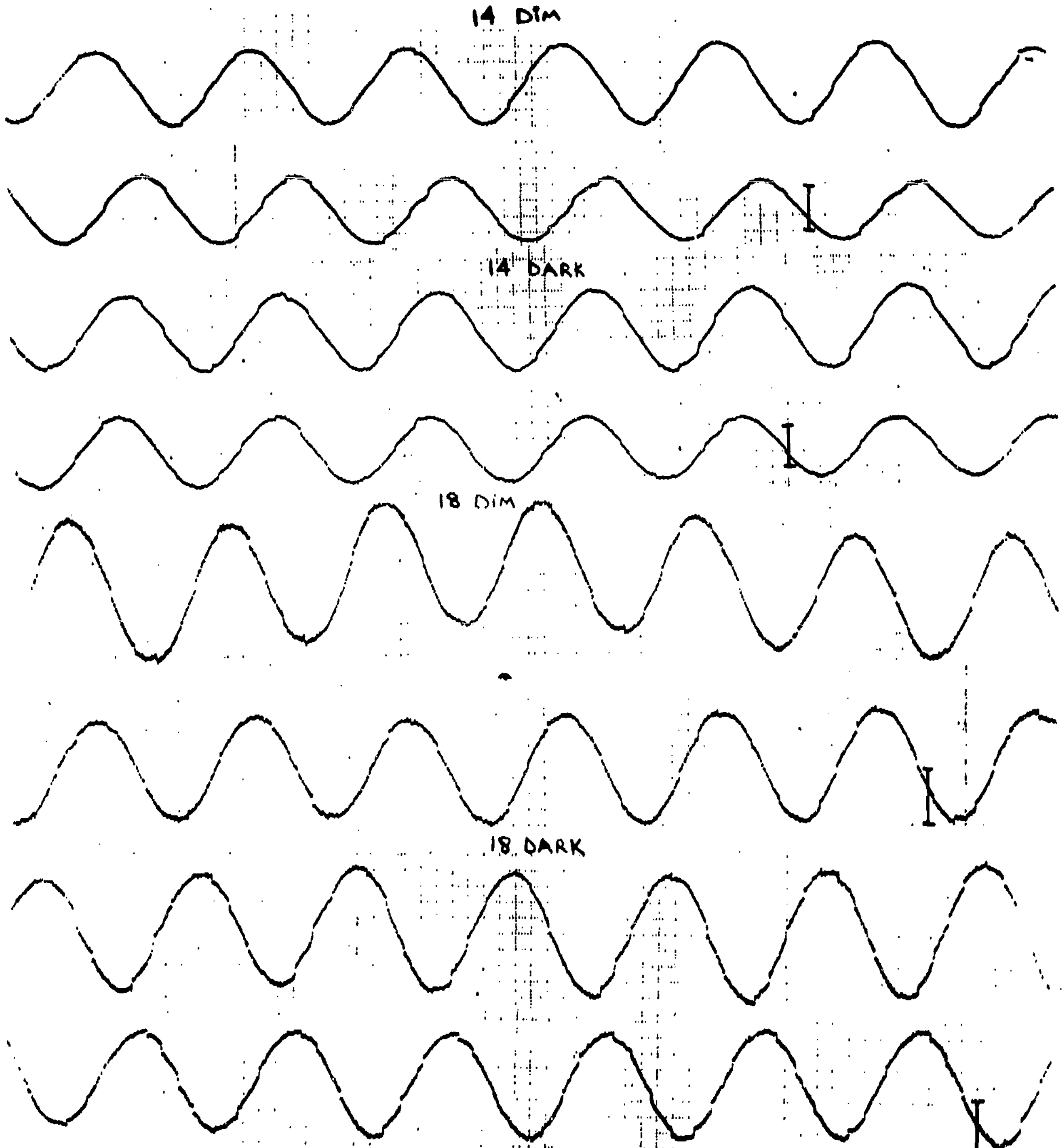

Figure 24

Pendular Eye Tracking Records from Two Individuals under the Two Viewing Conditions. Calibrations (vertical markers) indicate ±10-degree horizontal eye displacement. Each major horizontal division of record grid is 0.2 second.

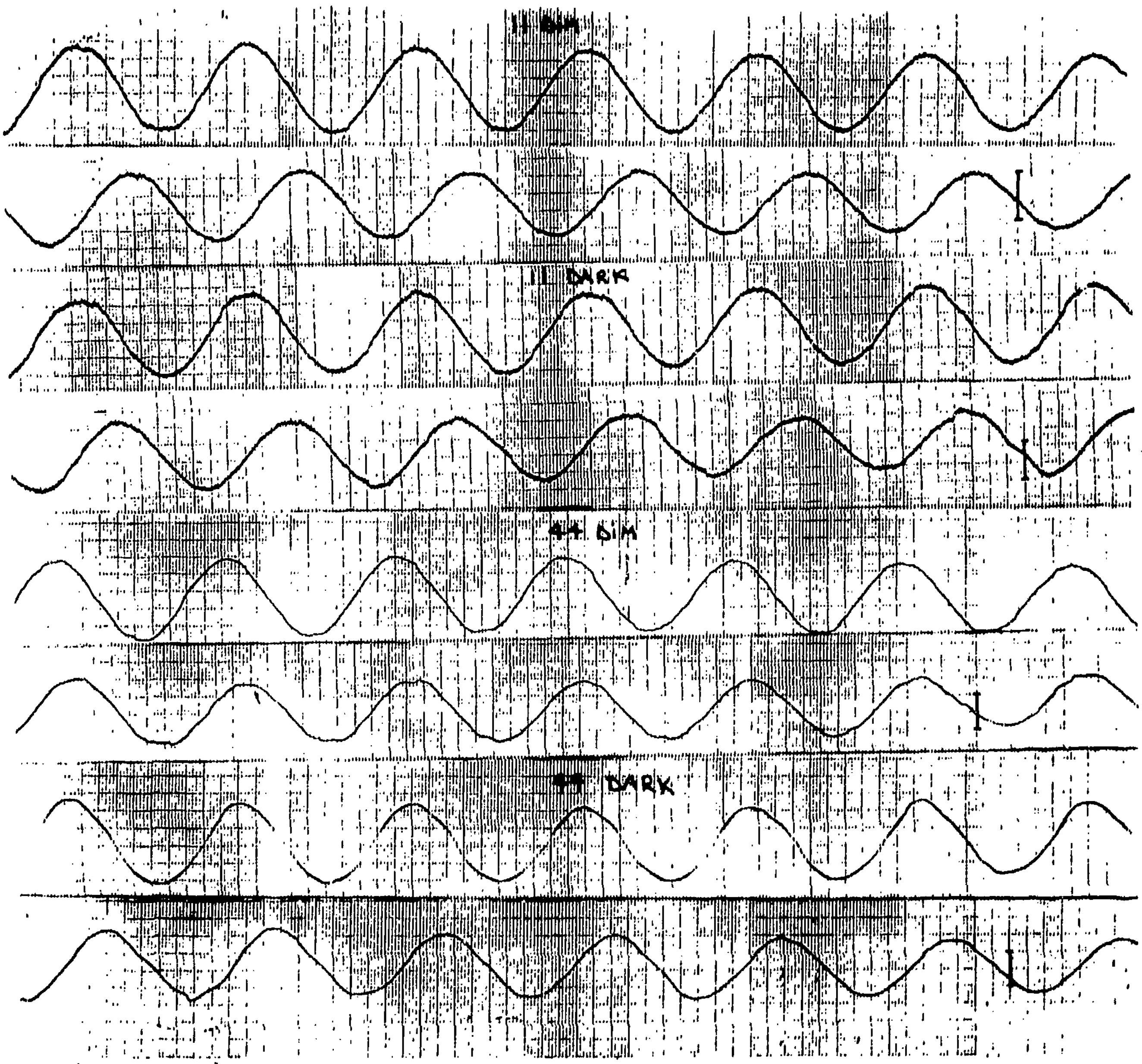

Figure 25

Pendular Eye Tracking Records from Two Individuals under the Two Viewing Conditions. Calibrations (vertical markers) indicate ±10-degree horizontal eye displacement. Each major horizontal division of record grid is 0.2 second.

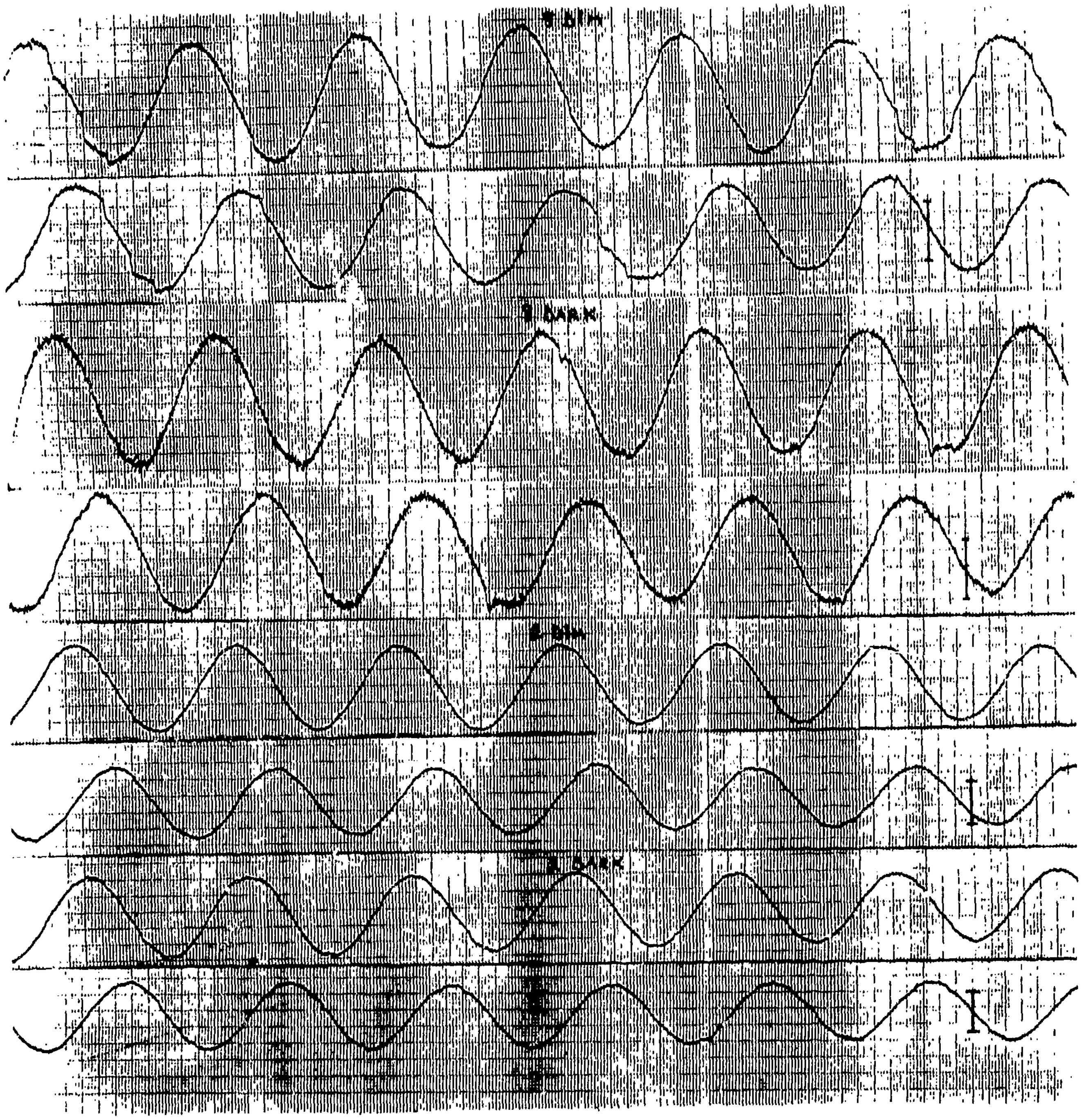

Figure 26

Pendular Eye Tracking Records from Two Individuals under the Two Viewing Conditions. Calibrations (vertical markers) indicate ±10-degree horizontal eye displacement. Each major horizontal division of record grid is 0.2 second.

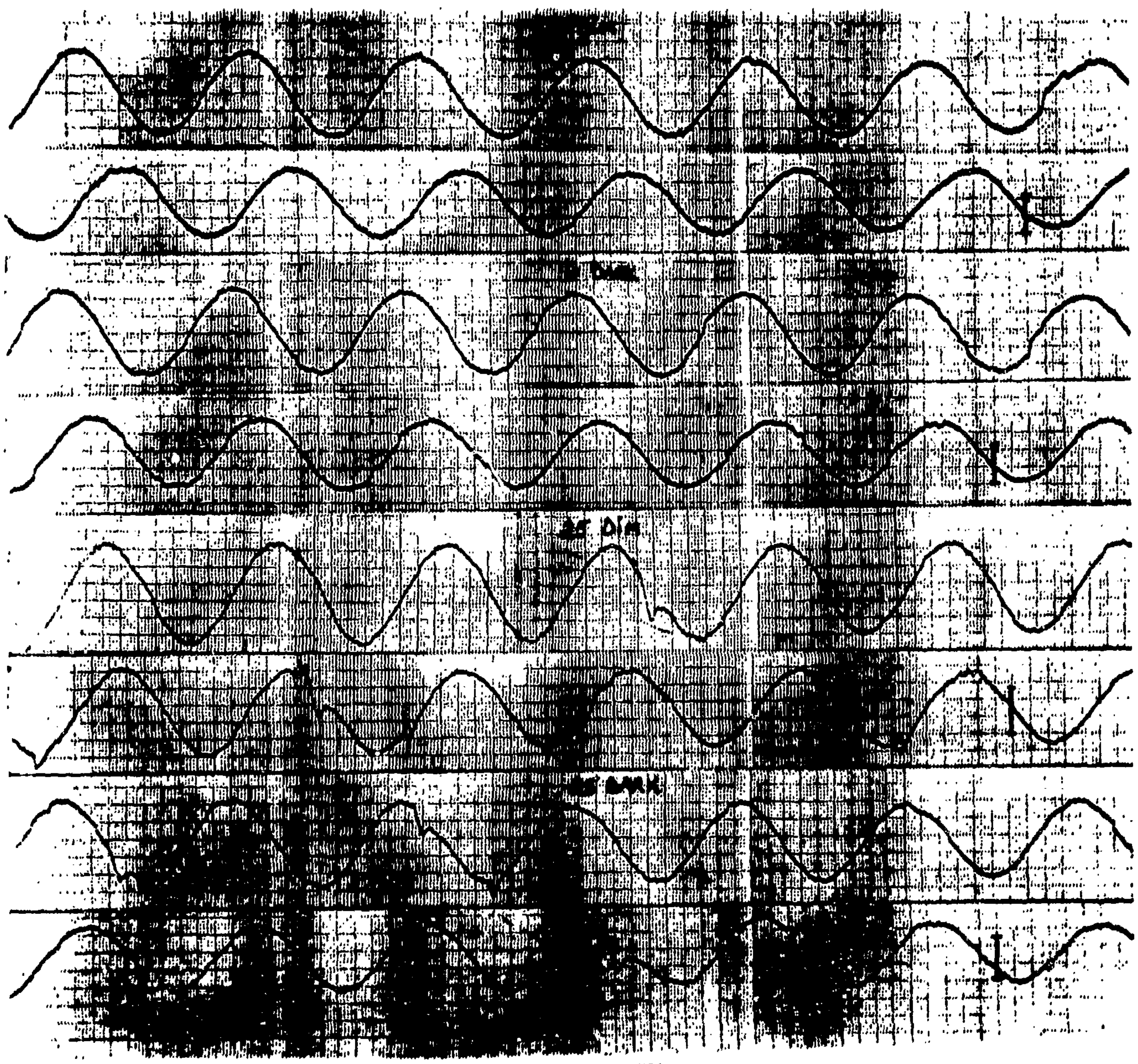

Figure 27

Pendular Eye Tracking Records from Two Individuals under the Two Viewing Conditions. Calibrations (vertical markers) indicate ±10-degree horizontal eye displacement. Each major horizontal division of record grid is 0.2 second.

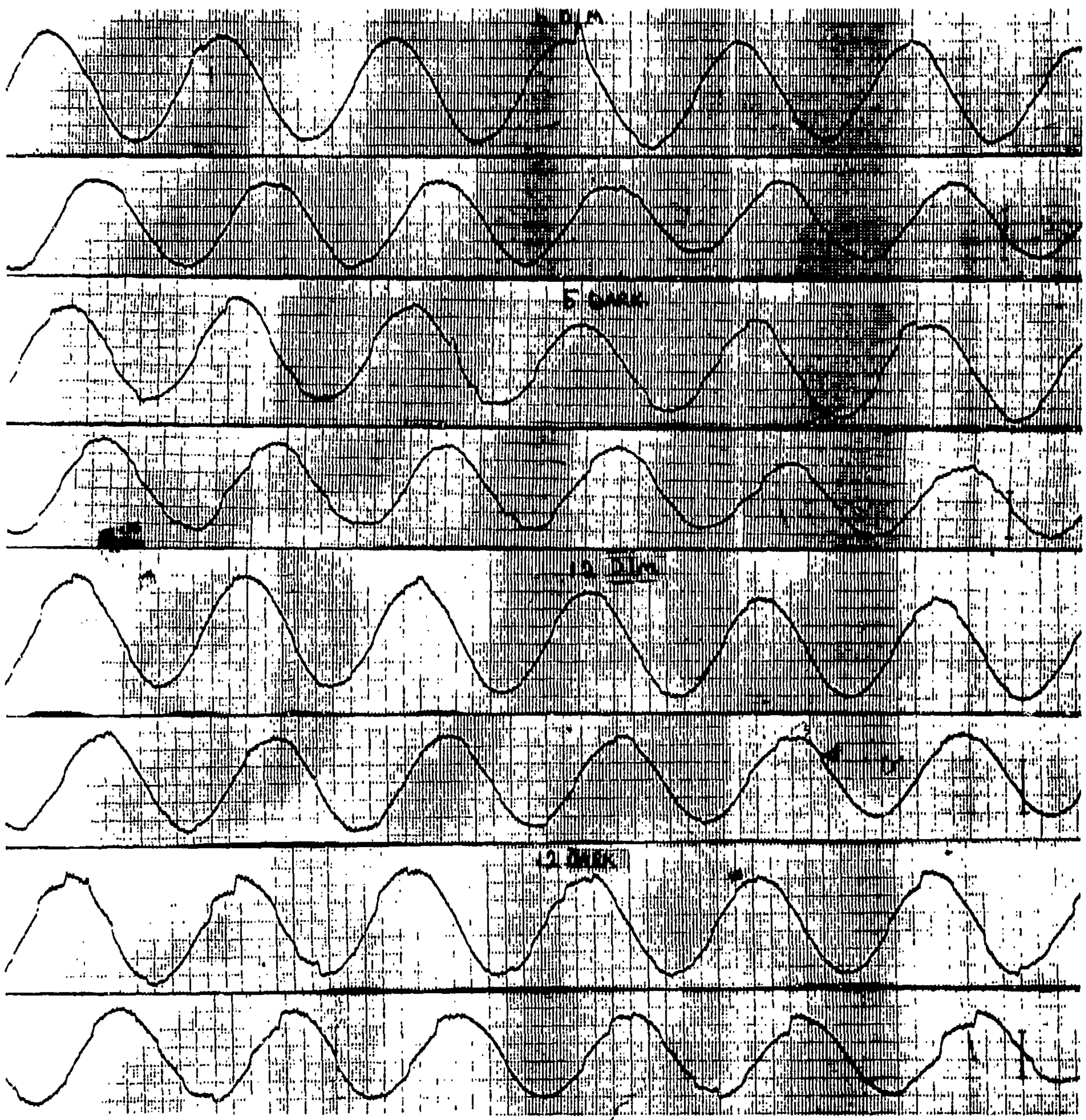

Figure 28

Pendular Eye Tracking Records from Two Individuals under the Two Viewing Conditions. Calibrations (vertical markers) indicate ±10-degree horizontal eye displacement. Each major horizontal division of record grid is 0.2 second.

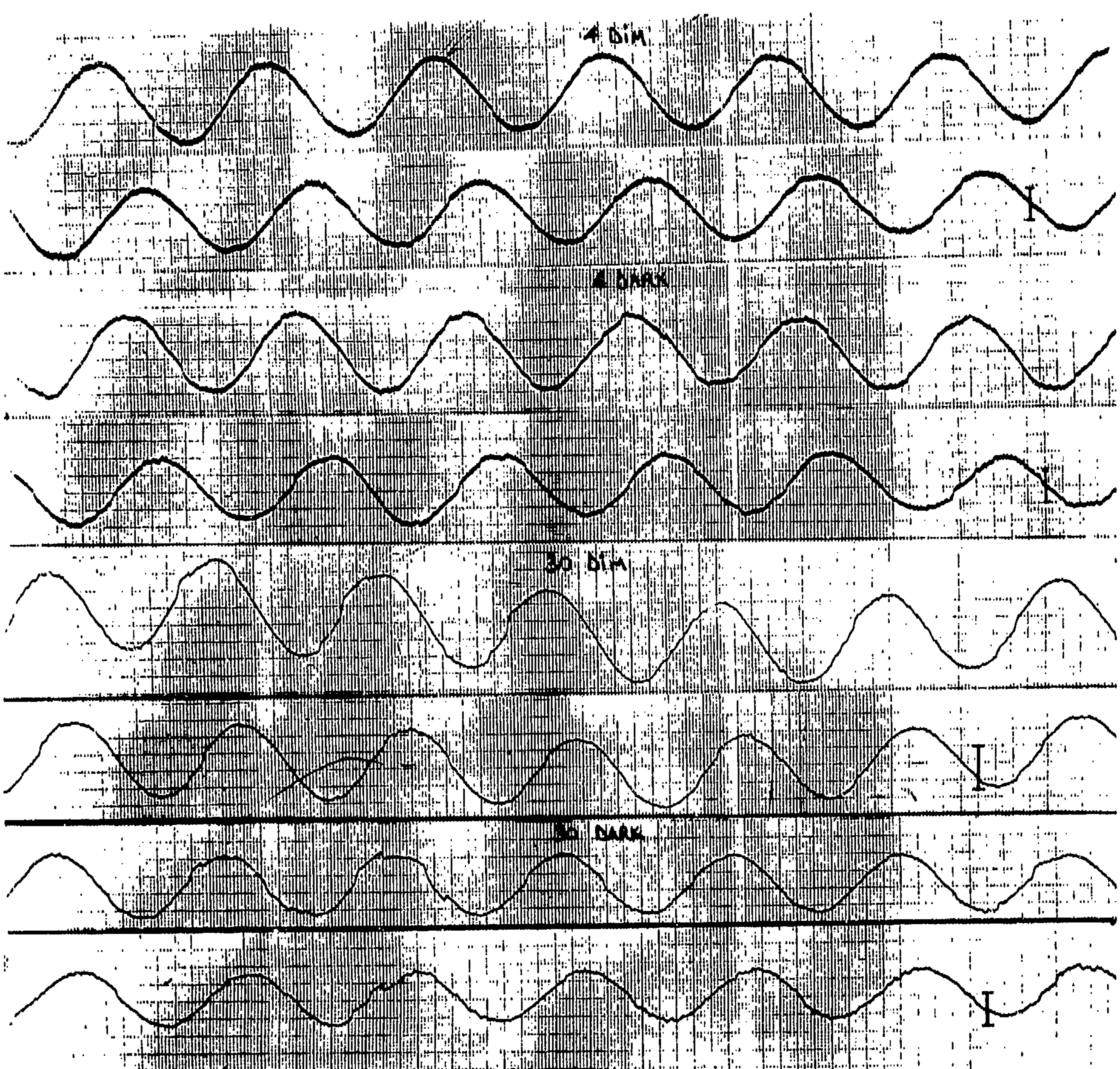

Figure 29

Pendular Eye Tracking Records from Two Individuals under the Two Viewing Conditions. Calibrations (vertical markers) indicate ±10-degree horizontal eye displacement. Each major horizontal division of record grid is 0.2 second.

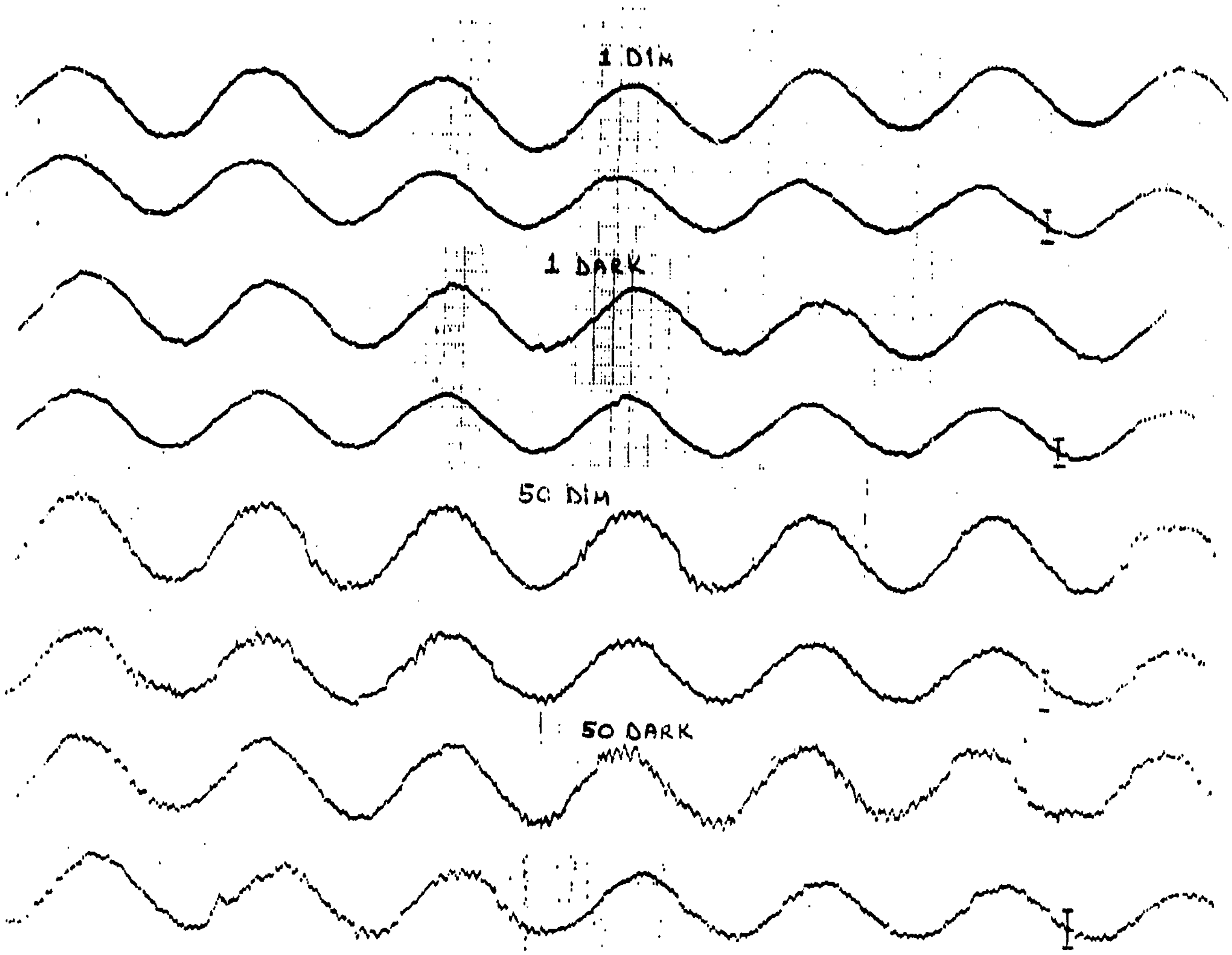

Figure 30

Pendular Eye Tracking Records from Two Individuals under the Two Viewing Conditions. Calibrations (vertical markers) indicate ±10-degree horizontal eye displacement. Each major horizontal division of record grid is 0.2 second. Irregularities noted during static-fixation recordings of Subject 50 suggest that the "cogwheel" appearance is an artifact independent of visual pursuit.

VISUAL PURSUIT OF POINT LIGHT SOURCE (S no. 83)

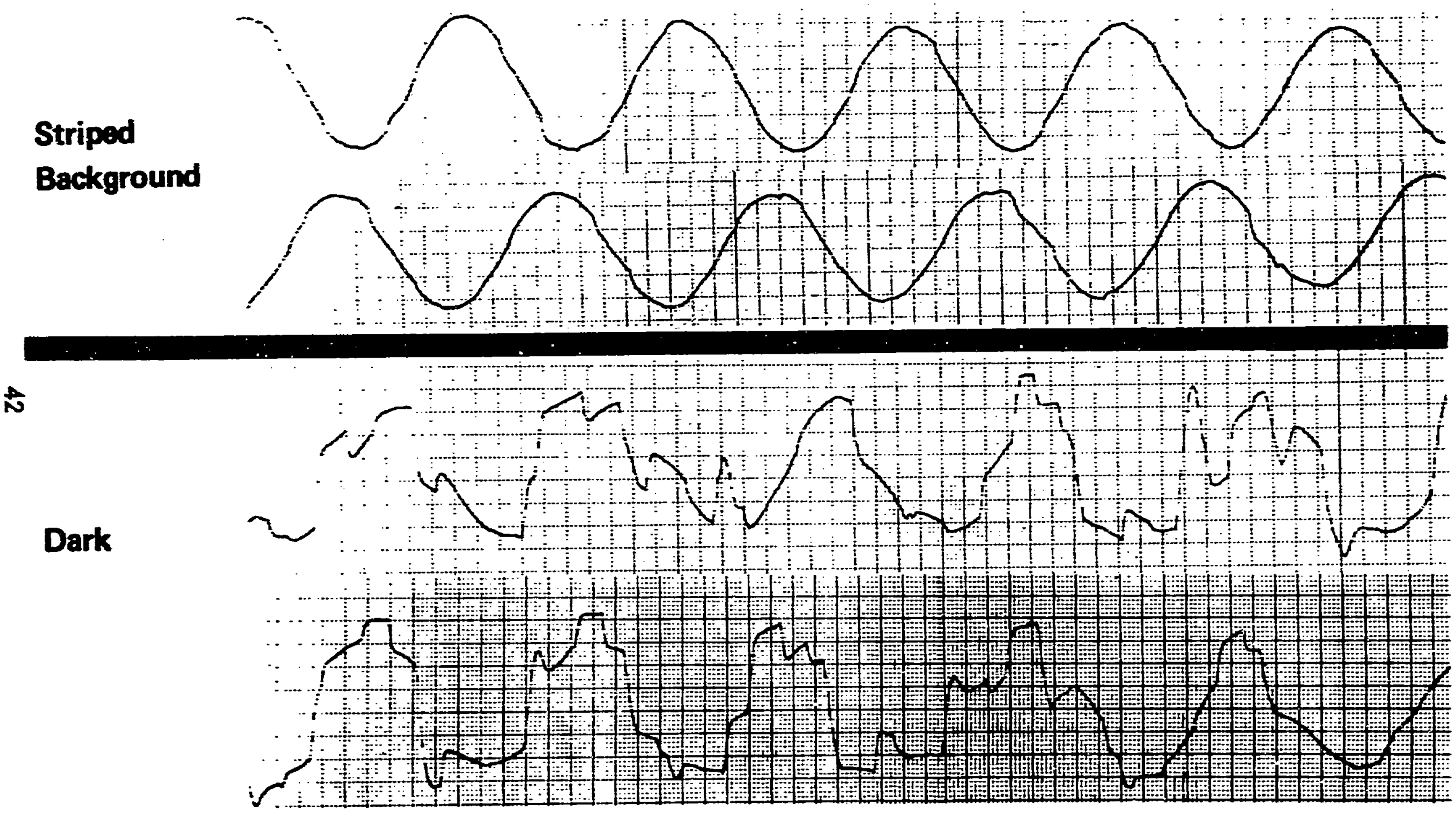

Figure 31

Extreme Differences in Pendular Eye Tracking in One Individual (not one of 60 subjects from Part I) under the Two Viewing Conditions. Differences persisted throughout each test and were equally prominent in a second test on another day.

APPENDIX A

Raters' Scores for Each Subject in Two Viewing Conditions

	Rater 1		Rater 2			Rater 1		Rater 2	
	Condition					Condition			
Subject	Dim	Dark	Dim	Dark	Subject	Dim	Dark	Dim	Dark
1	7	6	7	6	31	7	6	7	7
2	7	7	7	7	32	6	5	4	5
3	6	7	7	7	33	7	6	6	5
4	6	5	6	5	34	6	5	4	4
5	6	5	6	5	35	7	6	6	5
6	7	6	6	5	36	6	5	5	3
7	7	6	7	6	37	7	6	6	6
8	5	6	4	5	38	5	5	5	5
9	6	4	5	4	39	7	6	6	4
10	5	4	4	2	40	7	6	5	5
11	7	7	7	7	41	7	7	5	5
12	6	4	6	3	42	7	6	6	6
13	6	4	5	3	43	7	7	7	6
14	7	6	7	6	44	7	7	7	7
15	6	4	5	3	45	2	2	1	2
16	7	7	7	7	46	6	4	5	4
17	6	5	5	4	47	6	5	5	3
18	7	6	6	5	48	6	5	7	6
19	7	6	6	5	49	6	5	4	4
20	7	3	7	4	50	4	3	3	2
21	2	3	4	3	51	6	4	5	2
22	6	5	5	4	52	6	5	6	5
23	6	6	6	5	53	4	3	5	4
24	7	7	5	6	54	7	6	5	4
25	6	4	5	3	55	7	4	6	5
26	5	4	5	3	56	7	7	6	6
27	6	6	6	6	57	6	6	5	5
28	7	7	6	6	58	5	5	5	5
29	7	6	6	6	59	6	6	6	5
30	6	5	6	5	60	7	6	7	7

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18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Vertigo assessment; Visual pursuit; Peripheral vs. foveal retina; Pendular Eye Tracking Test

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Visual pursuit tracking of a sinusoidally moving target is a useful diagnostic aid in individuals with presenting symptoms of vertigo and disequilibrium. This test is conducted under various conditions that may influence both the variability of response among normal subjects and the pathognomic significance of the test. Normative data were collected from 60 subjects under two conditions of viewing a moving target, with and without a visible background. Smooth pursuit tracking of a target moving sinusoidally at 0.5 Hz with peak velocities ranging from 60 deg/sec to 30 deg/sec was slightly but fairly consistently superior

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under the former condition, i.e., with a visible background of vertical black and white stripes. It is suggested that the peripheral retina aids in visual pursuit tracking and that the test should be conducted under both viewing conditions since partially different systems are sampled by the two procedures.

Guedry, F. E., Jr.
K. S. Davenport, C. B. Brewton, G. T. Turnipseed

1979

THE PENDULAR EYE TRACKING TEST UNDER TWO BACKGROUND VIEWING CONDITIONS. NAMRL-1257. Pensacola, FL: Naval Aerospace Medical Research Laboratory, 9 January.

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